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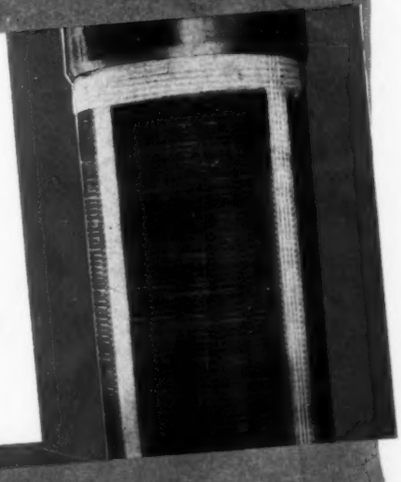

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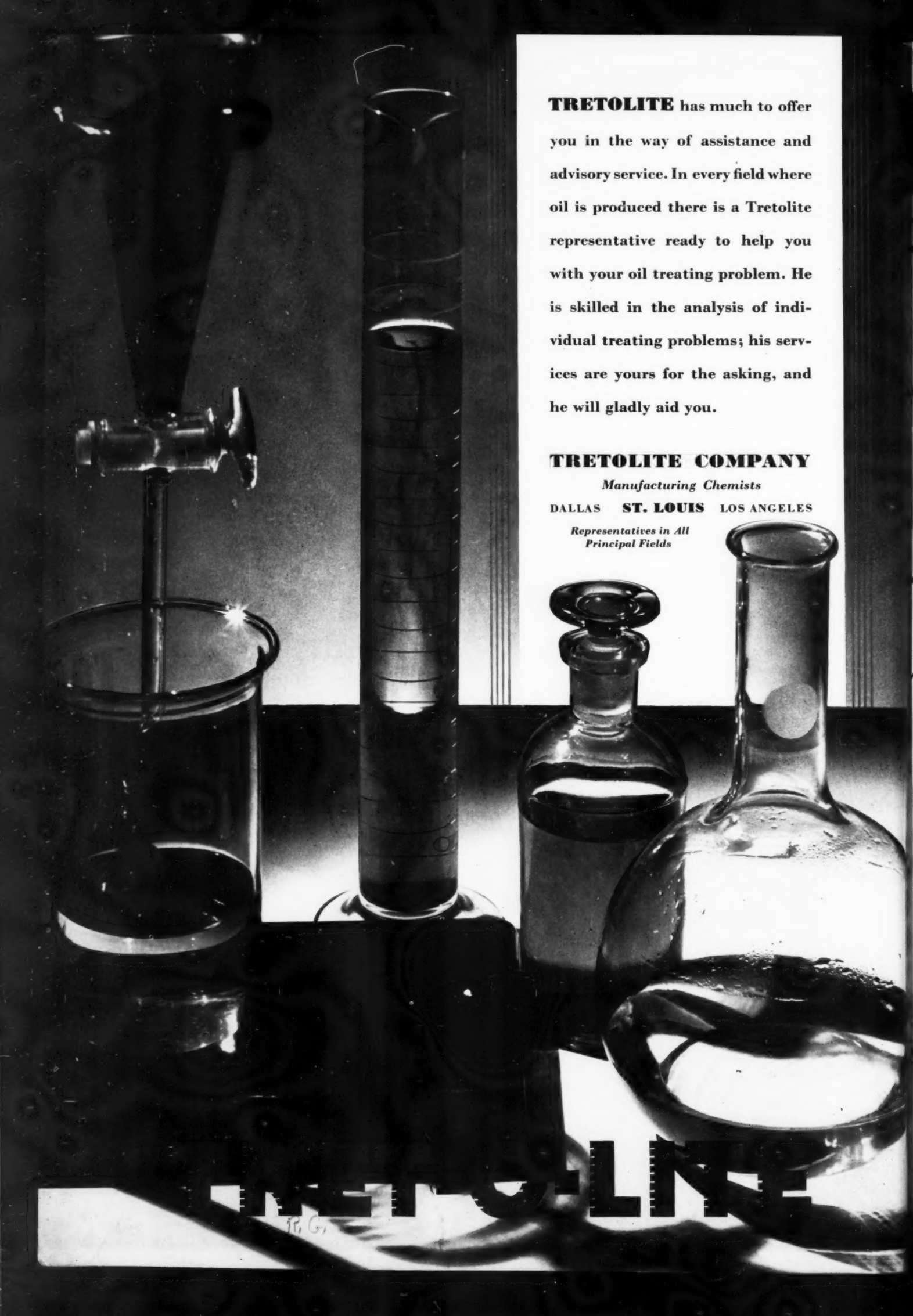
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OCTOBER, 1940

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The Course of Oil

By K. C. SCLATER

Incredible Antitrust Charges An imposing bill of complaints has been filed in the United States District Court by the Department of Justice in Washington against twenty-two major oil companies and the American Petroleum Institute.

The companies named in the complaint are said to own or control sixty percent of the crude oil reserves, fifty percent of the production of crude oil, ninety-two percent of the stocks of crude oil, seventy-five percent of the crude oil storage capacity, seventy-six percent of the crude oil refining capacity, eighty-seven percent of the cracking capacity, and eighty-five percent of gasoline production.

Apparently, bigness is under deliberate attack.

Among the complaints are that the defending companies have conspired to fix uniform, non-competitive prices for crude oil, restrict the production of crude oil and the manufacture of petroleum products. The American Petroleum Institute is alleged to have played a part in bringing about these restrictions by a system of reports covering the amounts and locations of all stocks of petroleum products. It is complained that the unreasonable power possessed and exercised by the integrated companies has deprived the consumer of natural resources due to location and that it has withheld from the consumer the benefits of technological improvement, which should be reflected in lower costs.

The allegations are nothing short of incredible. To read the bill of complaints against the twenty-two major oil companies one would think the petroleum industry one of unbridled avarice and shady dealings and the Petroleum Institute a clearing house for schemes for mulcting the public.

Not all the integrated companies are among the majors. Many substantial integrated companies in the oil industry are among the independents. Most of the research and technological improvements in the industry have been made by integrated companies. By virtue of integration they have increased the efficiency of their operations and so have the resources and personnel to carry on research. Research and technology have been among the greatest factors contributing to efficiency and economy in the petroleum industry and its remarkable record of progress, one result of which is that gasoline and petroleum products are procurable by the general public at prices that are by far the lowest of any in the world today.

"It is believed that the great advances and technological improvements in the oil industry are not being passed on to consumers." So it is stated in the bill of complaints. Certainly the facts refute this statement. Despite the fact that the taxes on gasoline have increased steadily over a period of years, the price of gasoline to the consumer has been reduced. How these facts can be reconciled with the complaints is not apparent.

Allegations in the suit would delude the public into thinking that bigness and integration are detrimental to the public interest. As for integration, authorities agree that the social and economic advantages of integration are many. Opposition to integration may arise because of irregularities within the industry itself, but "it would be an irremediable and disastrous error to destroy integration in order to remove the cause for complaints at its competitive frontiers; rather would it be desirable to allow time for internal adjustments to these ends."

The very purpose of integration is to increase efficiency and reduce costs. A history of the rise of petroleum to its present leading place as an industry reveals that one of the greatest factors contributing to its success has been research; and many of the programs of research pursued by the oil companies themselves would not have been possible without integration.

From a study of the bill of complaints it would seem that a premium should be placed on efficiency and that the companies more efficient by virtue of their alertness are accused of conspiracy. How low prices are to be effected by raising the price of crude oil and insuring profits to the least efficient refiners is not divulged.

The control of prices as it exists within the petroleum industry is construed as a restraint of trade, while the part that federal and state taxes play in the control of prices is disregarded. Federal and state taxes on gasoline throughout the country are thirty to fifty percent of the selling price, and only recently an extra tax was levied on gasoline to raise funds for National Defense, an activity in the role of which petroleum is paramount.

Competition in the petroleum industry is so great that it is difficult for a company to keep ahead of its competitors. Unless a company is efficient in every branch of its operations, it is likely to go to the wall. The integrated company, by controlling its product from the time it comes from the well until it is placed on the market, is able to reduce its risk because it is able to coördinate its producing and refining facilities to a greater degree. It is also enabled to conduct research and technologic investigations and attain a greater degree of efficiency thereby. This is the sound procedure followed in reducing costs, and one that must be and is followed by the reputable oil company.

Foremost among the American Petroleum Institute's contributions to the industry are the standardization of equipment and the fostering of research and improved methods in producing and refining operations. By the Institute's standardization program alone great savings in the manufacture and use of equipment have accrued to the entire production division of the industry, not only in this country but throughout the world. Notwithstanding this record of accomplishment, which has brought about far-reaching operating economies in the production and refining divisions of the oil industry, the Department of Justice would have the American Petroleum Institute dissolved.

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« « HIGHLIGHTS IN OILDOM » »

Rule Governing Deviation From Vertical Considered

At a recent meeting of the Texas Railroad Commission the adoption of a statewide rule limiting the deviation from vertical of wells was considered, and upon developing opposition the matter was reset for discussion at the next state proration hearing.

Such a ruling was proposed by the Arkansas Fuel Oil Company, whose representatives explained that the request was motivated by the directional drilling of two offset wells on the east side of the East Texas field. J. B. Henderson, attorney for the company, said the wells were being drilled directionally so that one would be less than 100 ft. and the other less than 175 ft. from the property lines of the Arkansas Fuel Oil Company. Henderson and R. O. Garrett, the latter a petroleum engineer for the company, stated that such practice would defeat the commission's spacing rule as to uniform spacing and drainage, cause the drilling of otherwise unnecessary offsets, and work other hardships on offset operators.

The representatives of the Arkansas Fuel Oil Company did not propose a rule but submitted a copy of the Arkansas rule that requires variation tests at 500-ft. intervals and limits deviation in wells less than 150 ft. from a property line to 3 deg. from vertical; 150 to 300 ft., 4 deg., and more than 300 ft., 5 deg.

Rayburn Thompson, speaking for Pure Oil Company and Texas Gulf Producing Company, contended a state rule was unnecessary and suggested adoption of rules applicable to specific fields.

●

Suit Filed Against 22 Oil Companies and the A.P.I.

Suit has been filed in Federal District Court at Washington, D. C., against 22 oil companies and the American Petroleum Institute charging monopolistic control of virtually all the crude oil available for refining and the fixing of prices. Action was brought by the Justice Department of the United States Government.

It is charged that control of the crude oil by the defendant companies places independent firms at a competitive disadvantage. The complaint also charges that the maintenance of fixed prices has restricted or eliminated competition that would force the integrated companies to give the consumer the benefit of lower costs arising from technological improvement.

In asking the court to dissolve the A.P.I., the government contended that the organization was created by the defendant companies to promote the alleged illegal practices cited in the case.

The companies named in the suit include: Atlantic Refining Company, Barnsdall Oil Company, Cities Service Oil Company, Consolidated Oil Corporation, Continental Oil Company, Gulf Oil Corporation, Mid-Continent Petroleum Corporation, Ohio Oil Company, Phillips Petroleum Company, Pure Oil Company, Shell Union Oil Corporation, Skelly Oil Company, Socony-Vacuum Oil Company, Standard Oil Company of California, Standard Oil Company of Indiana, Standard Oil Company of Kentucky, Standard Oil Company of New Jersey, Standard Oil Company of Ohio, Sun Oil Company, The Texas Corporation, Tide Water Associated Oil Company, and Union Oil Company of California. Approximately 300 subsidiaries of the companies also were named.

Refinery Capacity Greatest in History of Industry

Further assurance of the ability of the oil industry to supply increasing amounts of petroleum products whenever national welfare demands it, is found in the continued growth of the industry's refinery capacity. At the beginning of 1940, according to a recent report of the U. S. Bureau of Mines, the number of operating refineries and their daily refining capacity were at the highest peaks in the industry's history, and, the report indicated, were great enough to enable the processing of about 30 percent more crude oil than actually was refined during 1939.

The number of operating refineries had increased to 461 on January 1, 1940, from 435 on January 1, 1939, and their capacity to 4,196,694 bbl. of crude oil per day, from 3,933,785 bbl. the year before. The number of shut-down refineries declined, however, to 86 from 103, and the total capacity (operating and shut-down) of U. S. refineries increased at a slower rate to 4,628,646 bbl. on January 1, 1940, from 4,508,555 bbl. the preceding year. The year-end capacity compared with actual average crude oil runs to stills of 3,391,000 bbl. per day in 1939.

The increase in total capacity during 1939 represented the construction of 380,866 bbl. of new capacity in existing as well as new plants, and the retirement by dismantling of 260,775 bbl., a net increase of 120,091 bbl. per day.

More than four-fifths of the shut-down capacity, which includes plants completely shut-down as well as non-operating parts of operating plants, is in good condition, according to the report. Of the total shut-down capacity of 431,952 bbl. on the first of the year, only 71,055 bbl. was classified as in poor shape. This indicates that U. S. refineries, not considering problems of supply and distribution, operated on the average last year only at about 70 percent of capacity, and could, if called on, process about one-third more crude oil than they did.

●

Advance Schuler Field Crude Oil Prices

The Phillips Petroleum Company, on October 3, advanced its crude oil postings for Jones sand crude oil in the Schuler field, Arkansas, and made the prices retroactive to September 27. The new quotations, which equal those posted by the Standard Oil Company of Louisiana, have a top of 95 cents a bbl. for 40 gravity and higher, with 2 cents a bbl. differential down to 63 cents for 25 gravity and lower. The advanced prices are 12 cents a bbl. higher than previous postings in the Schuler area.

●

4331 East Texas Wells Producing Water With Oil

According to a report filed with Dr. F. V. L. Patten, chief engineer of the Texas Railroad Commission, 4331 of the more than 25,000 wells in the East Texas field are now producing water with the oil. Daily average withdrawals of water from these wells amount to 187,811 bbl. The per-well average is 43.31 bbl., which means in most cases that more than 2 bbl. of water are produced with each bbl. of oil.

The water-producing wells are divided into three classifications: 793 flowing wells, 3223 pumping wells, and 320 wells using air and gas lift.

The report, which covers all wells artificially produced or making water, revealed there are now 6230 pumping wells in the field and 767 wells produced by air or gas lift.

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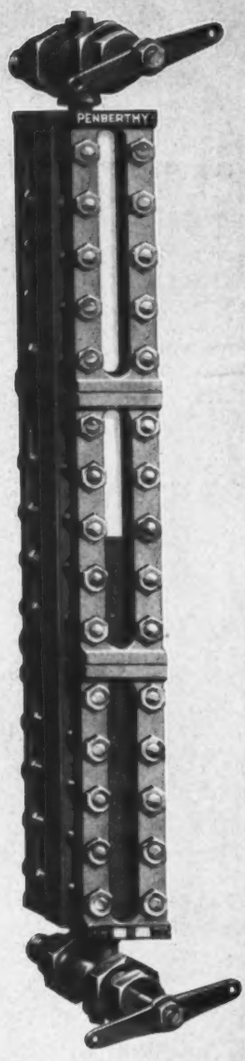

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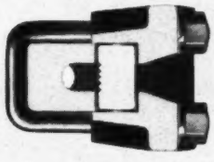

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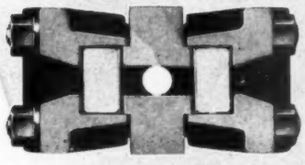

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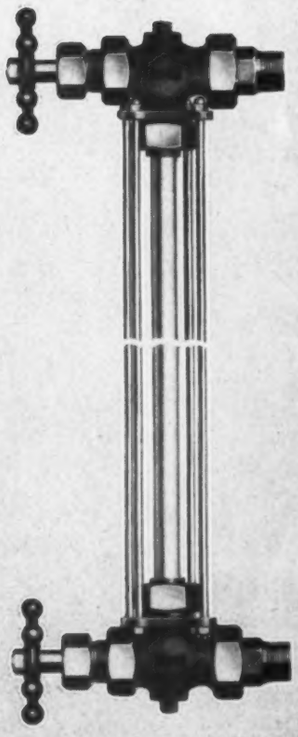

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PENBERTHY PRODUCTS

Activities in the Oil Fields

H. L. HUNT has opened a new oil pool five miles south of Jena, LaSalle Parish, Louisiana, with Goodpine Lumber Company No. A-2, in Section 9-7-3. After gun-perforating from 3679-83 ft. in the Wilcox sand, the well gauged 800 bbl. of oil per day producing through two ¼-in. chokes. Pressure on the tubing was 425 lb. and on the casing 1150 lb.

Location of the well is several miles south of the Olla area proper, which has 52 Wilcox wells.

●

Shell Oil Company, Inc., has discovered a new Wilcox producing area two miles southeast of Stroud, Creek County, Oklahoma, in Linihan No. 1, NE SE NE of 31-15-7. Drilled to a total depth of 4119 ft., the well flowed 45 bbl. in 24 hours, cutting 3 percent basic sediment and water. The Wilcox formation was found at a depth of 4070 ft.

●

Jones and Shelburne's Lewis No. 1, in SWC NE of 28-14-12w, Russell County, Kansas, opened the state's 25th new pool for 1940. The pool has been designated Greenvale North, the Greenvale pool being two miles to the south.

The well was drilled to a total depth of 2329 ft. and produced 1463 bbl. per day from the Howard lime.

●

Dunnworth No. 1 of Ora A. Avery, in 13-6s-11w, St. Joseph County, Michigan, 15 miles north of the Indiana line, produced gas and free oil after a 200-qt. shot at 2673 ft. The shot caused the hole to cave and delayed an accurate production test.

If established as a commercial producer, this wildcat will be the first Trenton lime producer in Michigan outside of the Deerfield pool in Monroe County.

A new producing area for Starr County, Texas, seems assured with the bringing-in of Sun Oil Company's Mateo Saens No. 1, three miles northeast of the North Rincon discovery. After being perforated at 5478-81 ft., the well cleaned-up and produced 19.6 bbl. of oil and no water in 3 hours, flowing through 7/32-in. choke. The size of the choke was changed to 7/64 in. and the well produced 14 bbl. in 5 hours.

●

Mid-Continent Petroleum Corporation's Ferguson No. 1, NE SW SW of 18-7-8, Seminole County, Oklahoma, flowed 90 bbl. of oil in 24 hours, opening a new Gilcrease sand producing area. In addition to the oil, 14,000,000 cu. ft. of gas was produced. Flow followed gun-perforation of the casing at a depth of 3230-36 ft.

●

The Texas Company has extended the Delta Farms field of Lafourche Parish, Louisiana, into Jefferson Parish with completion of its State Bayou Perot No. 1. This well was drilled below 11,400 ft., but was plugged-back and completed at a depth of 8770-8815 ft., producing 750 bbl. of oil per day through ¼-in. choke.

●

The Eaves pool, southeastern Lea County, New Mexico, has been extended ¾ mile to the west by Hamon Krupp and A. H. Flaherty's Moberly-State No. 1-C in C NW SE of 21-26e-37s.

Total depth of the well is 3254 ft. with the producing sand found at 3170 ft. Production is estimated at 500 bbl. of oil and 1,500,000 cu. ft. of gas per day.

The well is one of the few oil producers in this gas area. and seemingly is the best of the lot.

AVERAGE CRUDE OIL PRICES

California		Louisana	
Kettleman Hills	$1.12-1.38	Rodessa	$1.05
Playa Del Rey	.65-1.08	Gulf Coast	.79-1.28
Coalinga	.60- .82	North Louisiana	.73-1.05
Wilmington	.64-1.14		
Montana	.80-1.10	Illinois	1.15
Wyoming	.35-1.30	Kentucky	1.05-1.20
Colorado	.90- .98	Indiana	1.00
New Mexico	.77-1.00		
Texas		Ohio	
North Central	.71-1.03	Lima	.90
Panhandle	.67- .96		
West Texas	.53- .95	Michigan	.81-1.18
Gulf Coast	.86-1.28		
Darst Creek	.96	Pennsylvania	
East Texas	1.10	Bradford	1.85
Talco	.65	Southwest	1.50
		Eureka	1.44
Kansas	.60-1.10	Buckeye	1.55
Oklahoma	.60-1.10	Corning	1.12
Arkansas	.63-1.05	Canada	2.10-2.17

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	[1]B. of M. Calculated Requirements (October)	Week Ended Oct. 5, 1940	Week Ended Sept. 7, 1940	Week Ended Oct. 7, 1939
Oklahoma	403,500	[2]413,800	421,700	408,800
Kansas	178,700	[2]191,150	165,750	144,050
Nebraska		[2] 1,000	200	
Panhandle Texas		81,150	76,500	77,400
North Texas		120,700	96,200	71,250
West Central Texas		28,750	29,650	25,850
West Texas		208,600	221,500	211,850
East Central Texas		63,500	78,650	86,100
East Texas		298,700	374,900	394,600
Southwest Texas		199,150	211,200	180,650
Coastal Texas		188,400	210,600	208,200
TOTAL TEXAS	1,305,200	1,188,950	1,299,200	1,255,900
North Louisiana		64,750	64,800	66,000
Coastal Louisiana		220,550	213,250	187,100
TOTAL LA.	274,200	285,300	278,050	253,100
Arkansas	70,700	71,450	73,250	66,000
Mississippi	9,000	[2] 19,200	28,650	
Illinois	405,200	357,200	380,000	330,500
Indiana	9,300	[2] 19,800	18,300	100,550
Eastern (Not incl. Ill. and Ind.)	86,400	92,100	90,350	
Michigan	53,900	50,150	52,250	68,000
Wyoming	75,200	80,500	71,100	64,150
Montana	17,700	17,900	17,750	16,250
Colorado	3,900	3,250	3,600	3,700
New Mexico	104,500	97,650	100,700	108,550
TOTAL EAST OF CALIF.	2,997,400	2,889,400	3,000,850	2,819,550
California	583,200	599,400	623,000	616,300
TOTAL U. S.	3,580,600	3,488,800	3,623,850	3,435,850

[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of October. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Nebraska, Mississippi and Indiana figures are for week ended 7 a. m. October 2.

FOR THE MOST EFFECTIVE Paraffin Solvents AVAILABLE

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OIL AND GAS WELL CHEMICAL SERVICE

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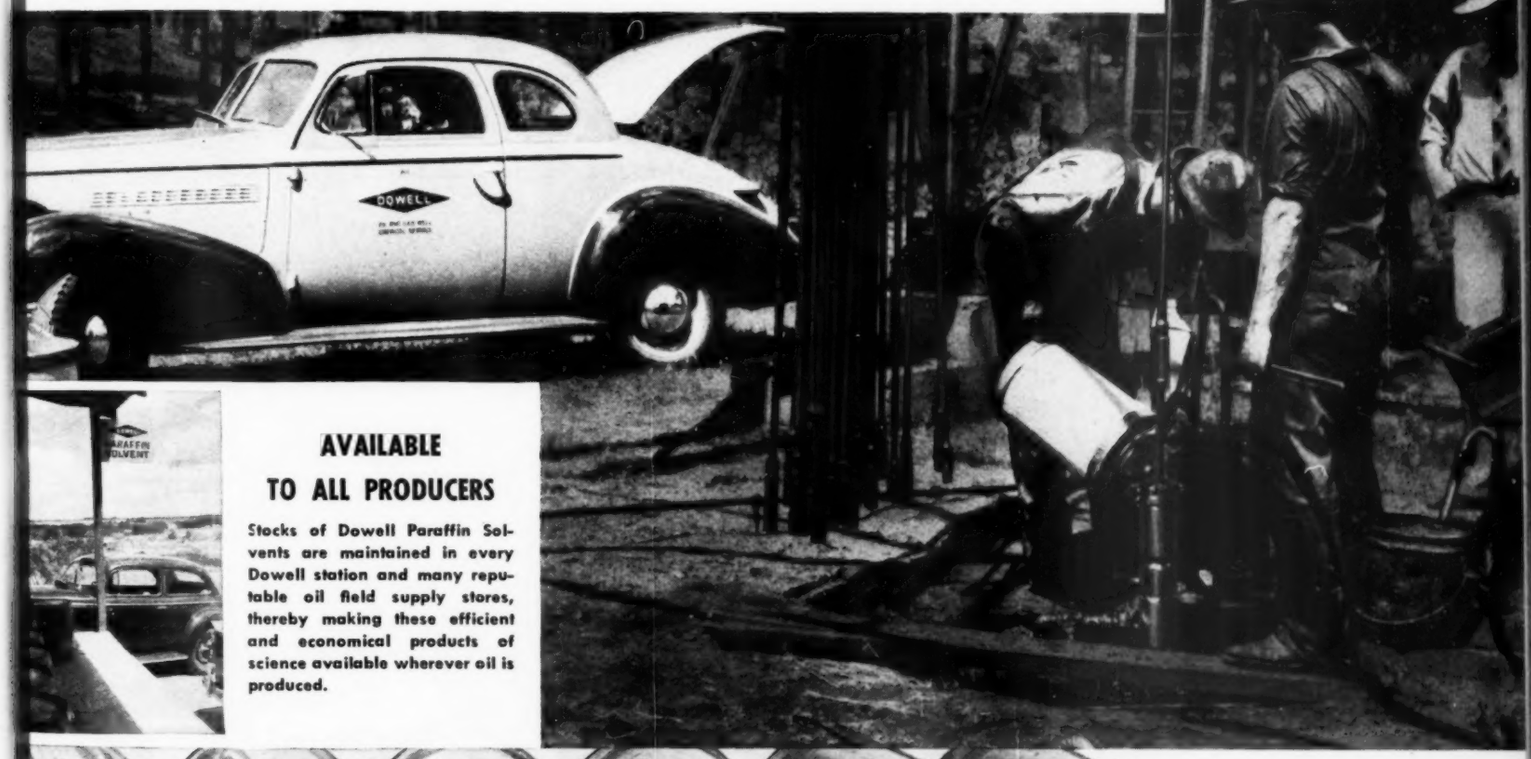

AVAILABLE TO ALL PRODUCERS

Stocks of Dowell Paraffin Solvents are maintained in every Dowell station and many reputable oil field supply stores, thereby making these efficient and economical products of science available wherever oil is produced.

ORANGE—Oil soluble, fireproof, concentrated liquid. Specific gravity 1.52; weighs approximately 13 lbs. per gallon. Intended for the removal of the denser types of paraffin. **PURPLE**—Oil soluble, non-inflammable, concentrated liquid with added wetting agent. Intended for removing the denser types of paraffin deposits. Especially applicable in the East Texas fields. **BROWN**—Oil soluble, weighted hydro-carbon solvent. Specific gravity 1.35. Alkaline type with detergent and cleaning properties greater than natural or acid solvent. Developed for the specific type of difficult paraffin deposits in California. **RED**—Oil soluble, concentrated liquid. Specific gravity approximately 1.25; weight about 10 lbs. per gallon. Inflammable, contains no hydro-carbons. Designed for mixing with carrying agent. Dissolves not only pure paraffin but impure deposits containing sulphur and asphalt. Softens stuck packer rubbers. **GREEN**—A heavy, inflammable, oil soluble liquid of high penetrating quality. Has detergent as well as dissolving action. Recommended for the Gulf Coast area. Especially applicable for removing impure and difficult paraffin accumulations. **BLUE**—An inflammable, hydro-carbon solvent. Specific gravity 0.84; weight about 7 lbs. per gallon. Efficient in removing the relatively pure types of paraffin. Absolutely non-corrosive, contains no chlorine or sulphur compounds, will not produce any corrosive effects or corrosive combustion products.

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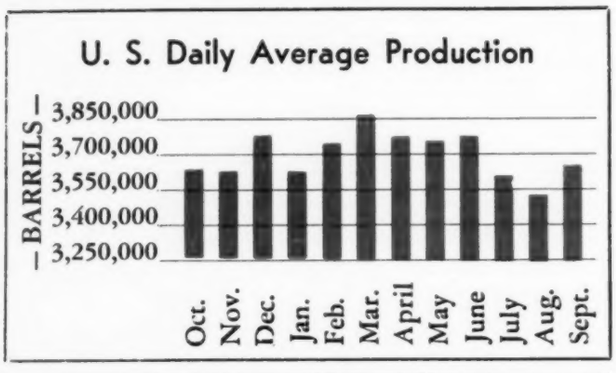
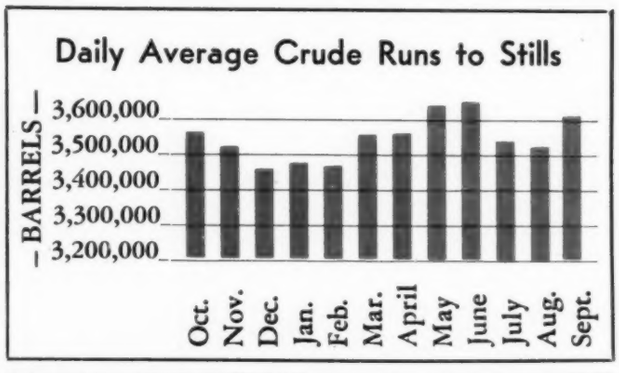
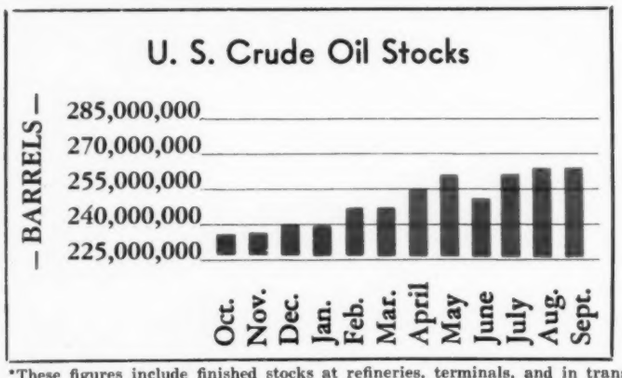
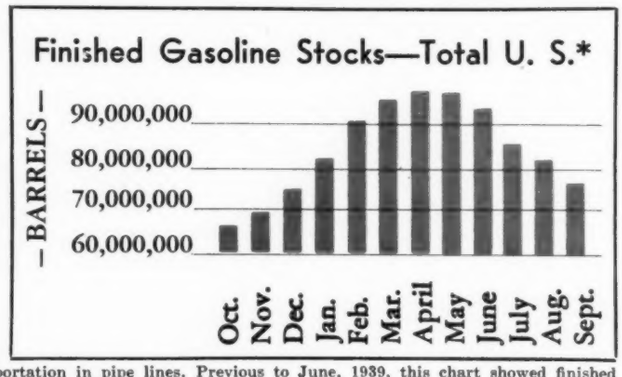
*Trade Mark Reg. U. S. Pat. Off.

Petroleum Statistics and Field Activities









*These figures include finished stocks at refineries, terminals, and in transportation in pipe lines. Previous to June, 1939, this chart showed finished stocks in refineries only. Above statistics by the American Petroleum Institute.

Summarized Operations in Active Fields for September, 1940

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	28	25	5	15	3500-3700	2	40	Rotary
Duval County	29	14	5	17	1554-2900	2	22	Rotary
Ector County	45	43	16	44	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	42	41	18	68	1700-3900	2	40	Rotary
Refugio County	6	6	2	4	4900-5900	2	38	Rotary
Nueces County	16	14	3	7	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	24	24	14	50	3730-3935	2	42-43	Rot.-Cab.
OKLAHOMA								
Fitts Pool	15	10	4	6	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	21	18	6	18	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	14	12	7	18	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	22	17	5	20	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	334	262	286	140	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	24	21	11	44	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	2	1	3	9	8300-8730	3 or 4	40	Rotary
Wilmington	16	16	12	11	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for September, 1940

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1939 (In Barrels)
	September	August	September	August	September	August	September	August	September	August	
Arkansas	12	13	9	7	16	10	3	6	28	27	21,266,994
California	106	105	95	97	83	88	80	76	175	171	224,336,682
Colorado	2	1	2	0	....	....	2	3	30	28	1,402,599
Illinois	334	415	262	313	481	404	286	295	140	146	92,915,620
Indiana	57	57	41	38	....	....	21	10	81	71	1,426,000
Kansas	181	197	137	165	177	197	33	36	230	238	59,952,340
Kentucky	39	37	21	17	....	....	9	11	92	80	5,611,500
Louisiana	135	128	115	103	128	135	31	33	166	164	94,110,736
Michigan	100	87	53	39	95	101	37	30	147	150	23,185,203
Mississippi	22	15	11	6	....	....	9	10	36	35	102,918
Montana	28	13	24	9	....	....	10	9	54	48	5,901,058
New Mexico	39	46	28	37	32	52	26	25	118	125	37,453,117
New York	76*	78*	75*	78*	....	....	10	11	62	65	5,105,000
Ohio	138	85	88	63	....	....	47	52	168	180	3,157,500
Oklahoma	173	179	118	127	138	184	36	42	252	270	156,421,939
Pennsylvania	275*	282*	265*	268*	....	....	....	....	....	....	17,342,500
Tennessee	....	....	....	....	....	....	....	....	....	....	....
Texas	729	821	552	622	800	833	349	375	1131	1252	485,847,999
West Virginia	48	33	41	28	....	....	23	25	150	144	3,556,500
Wyoming	17	16	15	12	....	....	9	10	73	75	21,408,478
Total	2511	2582	1952	2029	1950	2017	1021	1059	3133	3269	1,260,504,683

*Includes water-intake and pressure wells.

Activities in Refining

Percent Refining Capacity Operated

Western Division, 77.0 Percent **Central Division, 76.9 Percent** **Eastern Division, 87.0 Percent**

STANDARD Oil Company of Texas has announced its intention of constructing a recycling plant in the Sejita field, Duval County, Texas. The company is making contracts with lease, royalty, and land owners in the area and plans to consolidate all acreage on the mapped structure. Royalty owners will receive a proportionate part of 12½ percent (one-eighth) of the total output of the plant, their interest being divided by the amount of acreage held in the unit. The seven-eighths leaseholders will participate in the production on an overriding royalty basis, which would be calculated in a similar manner. Standard will drill all condensate wells, lay the gathering system, erect the plant, and arrange for the marketing.

The Standard Oil Company of Texas opened the Sejita field last year and has drilled several distillate producers since that time.

●

A new unit is being added to the plant of the Shallow Water Refining Company near Garden City, Kansas, which will make possible the manufacture of 72-74 octane leaded bronze gasoline from western Kansas crude oil.

The refinery is supplied with crude oil by the Shallow Water pool, Scott County, and the Aldrich pool, Ness County.

●

Construction of a 2000-bbl. refinery at Falls City, Nebraska, has been announced by Curtis Flint, Hynes, California, and Robert C. Druesdow, Omaha, Nebraska.

Initially, the refinery will be a topping plant, Flint states. Later cracking equipment may be installed to convert the heavier residual oils into gasoline.

Flint states that Falls City crude oil will produce about 10 percent straight-run gasoline. The rest will be converted to tractor fuel, Diesel fuel, kerosine, and various types of heating oils.

●

H. M. Prince of Jackson, Mississippi, plans the erection of a combination topping, cracking, and reforming plant at Yazoo City, Mississippi, to operate on crude oil from the Tinsley field.

Coastal Refineries, Inc., has announced an expansion program for its plant at Port Isabel, Texas. Additional storage tanks will be provided and a tetraethyl-lead blending plant erected. The refinery has a capacity of 6000 bbl. per day.

●

Ashland Oil and Refining Company, Ashland, Kentucky, has announced through its president, Paul G. Blazer, a program of expansion involving the expenditure of $650,000. This will include additions to its Leach refinery and to its river transportation facilities. The work will increase the refinery's capacity, which is now 10,000 bbl. per day, by 25 percent.

Additions to the refinery will include a vacuum-flash unit for production of asphalt, facilities for the shipment of asphalt in drums, equipment for generation of steam, and new storage tanks. A $250,000 tow boat and two 9000-bbl. capacity barges are to be built and will be used in transporting products up the Ohio River as far as Pittsburgh, Pennsylvania.

●

R. D. Swan, Joliet, Illinois, president of the Mid-States Refining Company, announces his company has acquired a 2500-bbl. refinery at Neosho Falls, Kansas, which is being dismantled for removal to Falls City, Nebraska.

Combustion Engineering and Construction Company, Houston, Texas, is moving the refinery, and it is expected the plant will be ready to begin operation about November 15.

Headquarters of the Mid-States Refining Company will be moved to Falls City, it has been announced.

●

Hudson Engineering Company, Houston, Texas, has been awarded the contract for construction of the coöperative recycling plant in the Cotton Valley field, Louisiana. Construction will be on a turnkey basis.

The plant will have a capacity of 150,000,000 cu. ft. per day and is expected to be in operation by the latter part of February or the early part of March, 1941.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended October 5, 1940
A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	542	84.3	19,848	30,748
Appalachian	91.0	123	86.6	3,375	1,206
Ind., Ill., Ky.	90.2	603	90.0	13,913	9,109
Okla., Kans., Mo.	76.9	267	82.7	6,181	3,858
Inland Texas	59.6	116	69.5	1,478	1,952
Texas Gulf	89.2	849	88.9	13,131	16,147
Louisiana Gulf	97.6	106	66.3	2,507	3,122
No. La. and Ark.	51.5	40	76.9	504	868
Rocky Mountain	56.0	56	82.4	913	567
California	87.3	523	71.6	15,466	85,294
Reported	86.2	3,225	82.5	77,316	152,871
Estimated Unreported		330		4,940	3,280
*EST'D TOTAL U.S. OCT. 5, 1940		3,555		82,256	156,151
*EST'D TOTAL U.S.SEPT. 28, 1940		3,600		82,373	156,436
U. S. B. of M. *OCT. 5, 1939		**3,562		71,367	152,576

*Estimated U. S. Bureau of Mines' basis.
**September-October, 1939, daily average.

Major Pipe Line Activities

PAN AMERICAN Pipe Line Company has begun construction of a trunk pipe line system from the East Texas field to tie-in with its present system at Sinco, east of Houston, Texas. A branch line also will be laid to serve the Cayuga field in Anderson County. The completed system will include gathering facilities in the East Texas field, a part of which will be constructed and a part purchased.

When the system is completed Pan American will be able to handle through its own facilities crude oil that is now being purchased by the Stanolind Oil Purchasing Company and delivered to Pan American's refinery at Texas City through the combined facilities of Humble, Stanolind, and Pan American, as well as the Cayuga crude oil being purchased by Pan American and delivered to the company's line at Sinco through Stanolind Pipe Line Company's facilities.

The branch line to the Cayuga field, which will be of 8-in. pipe and 67 miles in length, will tie-into the East Texas line at a point near Douglas. The main line from East Texas to that point will be of 10-in. pipe and approximately 58 miles in length, whereas from Douglas to Sinco, a distance of about 137 miles, the line will be 12 in. in diameter.

Main pumping stations will be erected in the East Texas and Cayuga fields, with three intermediate stations also to be constructed.

Pan American Pipe Line Company now owns a 12-in. trunk line from Sinco to Texas City, which also serves the Gillock and South Houston fields; and a separate 8-in. trunk line and gathering facilities that transport crude oil from the Hastings field to its Texas City refinery.

●

The Argentine State Oilfields Department has reported to the Ministry of Agriculture the need for a system of crude oil transportation from Mendoza to San Lorenzo that will take care of the steadily increasing production from Mendoza wells. A pipe line covering the 600-mile distance between Mendoza oil fields and the San Lorenzo refinery is suggested.

Oil is now shipped from the Mendoza fields by rail at a rate that is reported to increase the cost by 20 percent.

●

Magnolia Pipe Line Company has awarded to T. R. Jones of Dallas, Texas, the contract for laying an 8-in. pipe line from the company's Ringgold station in Montague County, Texas, across Clay County, into Archer County, to serve the Hull-Silk and K.M.A. areas. Work already has begun. The length of the line will be 42 miles.

●

Sinclair Refining Company, Pipe Line Division, is enlarging its facilities from the Walnut Bend pool, Cooke County, Texas, where it is the sole crude oil purchaser.

A 6-in. line will be laid from the field to Gainesville, where the company has a loading rack. A 4-in. line has been handling the production and the new 6-in. will parallel it.

●

The Bell Pipe Line Company of Nebraska has completed the laying of a 4½-in. pipe line from the field west of Falls City to a loading rack at Falls City, Nebraska. Here crude oil is being loaded into tank cars for shipment to various points in the North. The capacity of the line is 10,000 bbl. per day.

●

Curtis B. Dall, appeared before the Federal Power Commission in Washington, D. C., recently and asked approval of his plans for a $20,500,000 natural gas pipe line from Louisiana and Texas fields to Tennessee and North Carolina. He identified himself as a New York investment banker and president of the Tennessee Gas and Transmission Company, which seeks authority to pipe gas to Chattanooga, Nashville, Knoxville, and other Tennessee cities, and to Asheville, North Carolina.

The company's headquarters are in Chattanooga.

●

The 171-mile gasoline pipe line being laid from Buffalo to Syracuse, New York, for Socony-Vacuum Oil Company, Inc., by O. C. Whitaker Company is expected to be completed about November 1. This will make possible the transportation of gasoline from the company's Buffalo refinery to Rochester and Syracuse without the necessity of relying upon the Barge Canal, which is closed to navigation during the winter.

The line is being constructed of 4-in. and 6-in. pipe.

●

Soviet Russia has placed a contract for the purchase of 25,000 tons of 12¾-in. pipe to be laid in the Ural Mountains. The line will be 170 miles in length. Steel companies participating in the contract include National Tube Company, Jones and Laughlin Steel Corporation, Pittsburgh Steel Company, Spang Chalfant Division of National Supply Company, and the Youngstown Sheet and Tube Company.

●

Latex Construction Company has begun laying the Texas-New Mexico Pipe Line Company's new oil line from Midland, Texas, to the Slaughter and Duggan fields. Capacity of the system will be 8000 bbl. per day.

Approximately 22 miles of the line will be of 10¾-in. pipe, 82 miles will be of 8⅝-in., and 1 mile will be of 14-in.

●

Andrew F. Schoeppel, chairman of the Kansas Corporation Commission, and Hal Page, gas engineer for the conservation division of the commission, were in Madison, Wisconsin, recently to attend a hearing of the Federal Power Commission, where they received testimony relative to the granting of a pipe-line permit for transportation of natural gas into the state of Wisconsin. Phillips Petroleum Company, Natural Gas Pipe Line Company of America, and Paul Kayser of El Paso, Texas, have submitted applications for such a pipe line.

If the permit is granted the Hugoton gas field of southwestern Kansas may find an additional market for its huge reserves.

●

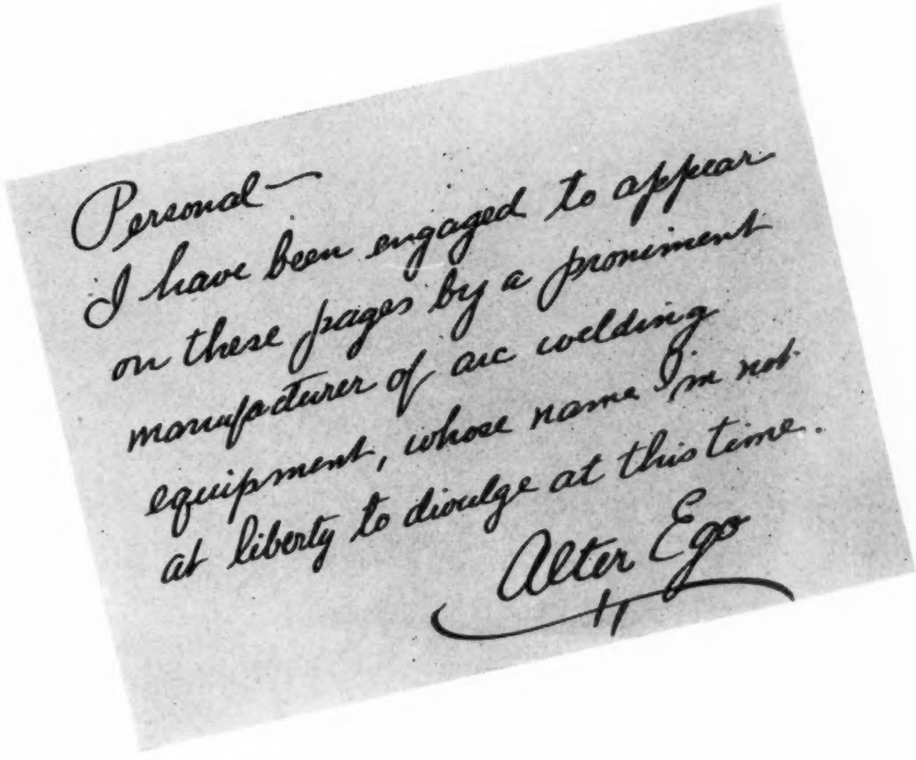
The Southern Natural Gas Company of Birmingham, Alabama, has announced it will lay a 120-mile natural gas line from Joaquin to Monroe, Louisiana, made necessary by declining production in the Monroe area. Through its subsidiary, Southern Production Company, a total of 6000 acres has been obtained in Shelby County, Texas, for development.

●

Drillers Gas Company, Wichita, Kansas, is laying an 8-in. line from Hutchinson to Lyons, a distance of 30 miles.

●

The contract to construct an 18-mile, 4-in. pipe line outlet for the Sugar Creek field, Claiborne Parish, Louisiana, has been awarded by the Triangle Drilling Company of Shreveport, Louisiana, to Wood Engineering and Construction Company of Arp, Texas.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on these pages by a prominent
manufacturer of arc welding
equipment, whose name I'm not
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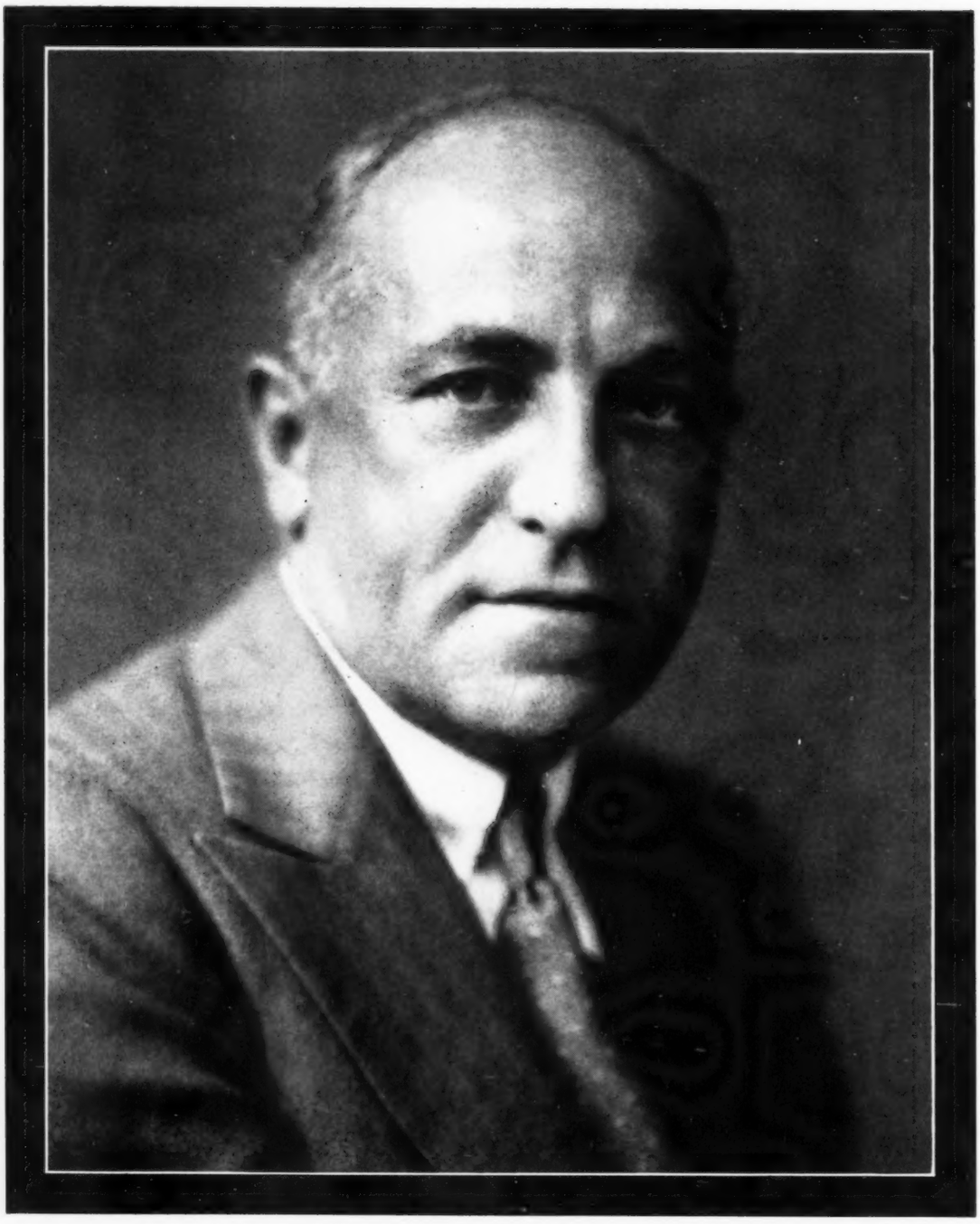


Clarence Morris

CLARENCE MORRIS, president and general manager of *The Petroleum Engineer*, passed away in Los Angeles, California, on September 18, death resulting from a heart ailment with which he had been afflicted for several years. ¶ The end came as he would have wished it—while he was in harness. He had returned to his apartment after making a business call, and was seated at his desk writing a letter to the Dallas office when seized with the attack. Doctors said his death was instantaneous. He was buried in Ventura, California, on September 20. ¶ Morris' affiliation with the oil industry dated back many years and he was regarded as having a keen insight into the industry's trends and its needs. When the International Petroleum Exposition was begun in 1923, he was a prominent factor in its early success. Although in no way connected with it in an official capacity he, nevertheless, devoted much of his personal time toward aiding that embryo event to become established. His enthusiasm for the Exposition grew out of his belief that an industry so great as that of petroleum would reap a vast benefit by staging a "Show" where improvements in equipment and methods could be displayed to the executive and field man. In later years he was a director of the Exposition. ¶ His forward thinking was again demonstrated when, in 1929, he and a group of associates, founded *The Petroleum Engineer*, to provide an oil publication devoted exclusively to the engineering and operating phases of the industry. This was at a time when but a limited number could foresee the extent to which the petroleum industry was to become technical and engineering "minded." ¶ One of his latest achievements in the publication field was when he presented to those in attendance at the 1940 International Petroleum Exposition the *Oil Show Daily*. This tabloid size newspaper, published on the Show grounds, depicted in word and picture the highlights of the Exposition. ¶ Born in Corpus Christi, Texas, in 1884, Morris was 56 at the time of his passing. He spent his childhood in Corpus Christi and before coming of age operated a district distributorship for a large meat-packing company. Later he became a professional baseball player, being a pitcher for the Waco club in the old North Texas League. During the off season he worked as a civil engineer on railroad construction gangs in various parts of the South and Southwest. He then entered the field of advertising, which profession, together with other phases of publication work, he pursued throughout the remainder of his life. ¶ His first connection with an oil publication was in 1916 with the *Oil City Derrick* in Oil City, Pennsylvania. A special edition called "The Domain of Oil and Gas" published by this paper was the result of his initiative. The following year he was instrumental in a special edition being published by the *Oil and Gas Journal* titled "North American Oil and Gas." Later he was placed in charge of the Pittsburgh territory for the latter magazine and subsequently became its advertising manager, making his residence in Tulsa, Oklahoma. He served in that capacity until 1929 when *The Petroleum Engineer* was founded. ¶ In addition to being a director of the International Petroleum Exposition, Morris was a member of the Nomads Club and the Beloved Vagabonds. He is survived by his widow, Mrs. May Morris; his mother, Mrs. C. Morris, Corpus Christi; three brothers, Gilbert Morris, Corpus Christi, David Morris, New York City, and Leopold Morris, Victoria, Texas; and one sister, Mrs. L. H. Baskin, Corpus Christi.

World Conditions Point to Increased Respon

By
WALLACE A. SAWDON
Pacific Coast and Foreign Editor

FORTY percent of the world's petroleum is produced in countries outside the United States. Under present world conditions the operations involved in producing and refining petroleum are beset with difficulties that are quite extraneous to those arising from climatic and geographical considerations.

It is imperative that the production and refining of petroleum be carried on at all costs regardless of the obstacles to be faced; for out of the welter of destruction in Europe the vital role that petroleum occupies becomes increasingly important. Although petroleum is one of the important sinews of war, it is equally vital and important in peace.

Who can tell how field development, producing, and refining operations in foreign fields will ultimately be affected by hostilities? Wholesale destruction of refining facilities in the warring countries is taking place. Oilfields, particularly those in the immediate theater of war, although practically untouched thus far by the warring machine, are likely to suffer extensive damage before it is all over. Stocks of crude oil and refined products of the belligerent nations are being wiped out at an unprecedented rate. Gasoline and lubricants are being consumed in vast quantities by the engines of war.

Reconstruction and replacement of refining and oilfield facilities and the replenishment of petroleum stocks for peace needs are among the problems that must eventually be faced.

Curiously enough, despite the large stocks of petroleum that are being destroyed and the quantities of gasoline and lubricating oil being consumed, the petroleum industry of the world has not been taxed to any extent to replace these losses. One reason, of course, is that regular channels of commerce are closed, and supplies cannot be replaced. Shipping facilities and schedules have been disorganized. Some foreign fields have suffered because of the lack of shipping facilities and the consequent piling up of oil stocks. Notable among the countries affected is Venezuela, which in 1939 was the third largest producing area in the world and second only to the United States and U. S. S. R.

WALLACE A. SAWDON

editor of the foreign section that follows, was a Captain of Engineers and saw active service in France during the first World War — He joined the staff of the U. S. Bureau of Mines in 1922 and later was a petroleum engineer for the Independent Oil and Gas Company—Subsequently he variously was engaged in consulting engineering work, was sales engineer for the Foxboro Company, and field editor of *Oil Field Engineering* — He moved to California in 1930 and makes his home in Hollywood — Sawdon has traveled extensively in South America and has numerous contacts with active oil men throughout the world — By training and experience and knowledge of foreign conditions he is well qualified as an editor and writer on foreign oil operations.

It is futile to attempt to predict what effect international hostilities will ultimately have on world oil-producing and refining operations. Only the outcome of hostilities will determine this. It is clearly evident, however, that drastic changes are in the offing.

Producing and refining operations in those countries outside the theater of war continue, but actual conditions of operation are in many instances difficult, to say the least. It is known, however, that exploration activities have been increased in many areas and that drilling and producing operations are being speeded-up as though in preparation for the period of replenishment that must inevitably come.

The matter of rehabilitation of the world petroleum industry after hostilities have ceased will be a stupendous task. How this rehabilitation will be effected is problematical. It is evident, however, that the American petroleum industry, its technicians, engineers, and manufacturers, will be called upon to lead in this work. Petroleum is essentially an American industry. Field exploration, exploitation, refining, and transportation methods have been developed in the United States and adopted in most of the leading oil fields of the world. It is quite probable therefore, that the technical, operating, and manufacturing forces of the petroleum industry of this country will be taxed to the utmost in supplying the needs of the petroleum industry in many parts of the world. When that demand comes, the American petroleum industry must be prepared.

Of interest to the American manufacturer of oilfield equipment is the present and the immediate future, and the period following the cessation of hostilities. It is probable that the bulk

sibilities of American Petroleum Industry

Technical, operating, and manufacturing divisions must prepare for the rehabilitation of the disrupted facilities of a war-racked world

of the export business for some time to come will be with South American countries. Whether or not the volume of exports to these countries will offset the loss of business with other countries cannot be assumed, although it is the opinion of some that such will be the case. At any rate, certain classes of oil equipment that were previously bought almost exclusively from European countries are now being purchased in the United States. There will, of course, be some shipments to countries in the Eastern Hemisphere but it is doubtful that these will attain any extensive proportions while the war continues. There is entirely too much uncertainty regarding interference with operations and safety in transportation to warrant any great expansion or increased development in the East Indian or Asiatic fields or refineries.

Business with South American countries during the war period, however, means more than just the present shipment of oil equipment. American equipment incorporates the results of years of experience and knowledge gained in the production of more than 60 percent of the total world production of oil during the last 35 years. Practically every known condition has to be met in the fields of the United States and the experience gained plus the research facilities and availability of materials have resulted in the design and construction of the most efficient oil tools and machinery in the world. Although American-made equipment has always been used to some extent in most countries, some of it is now being employed merely because cheaper, though less efficient, equipment cannot be purchased. There is an opportunity for American equipment to prove its value in service and superiority and obviate the possibility of supplanting it with cheaper and inefficient equipment that will probably be offered when peace-time output of factories is resumed.

The quality and performance of oil equipment from this country will speak for itself. Its design and construction will probably make its first cost greater than poorer designs but it will almost always prove more economical in the long run. It not only does the job better but in many cases decreases hazards and eliminates the high cost of urgent replacements necessitated by failures. To maintain and increase the sale of equipment after the war, particularly in South America, the American manufacturer can do much to increase a mutual understanding and, by fostering a closer relationship with the users of equipment, add to the deep regard his product attains in performance. An ever-increasing use of American oil equipment in South America is expected to continue during the war and for some time after the war is over.

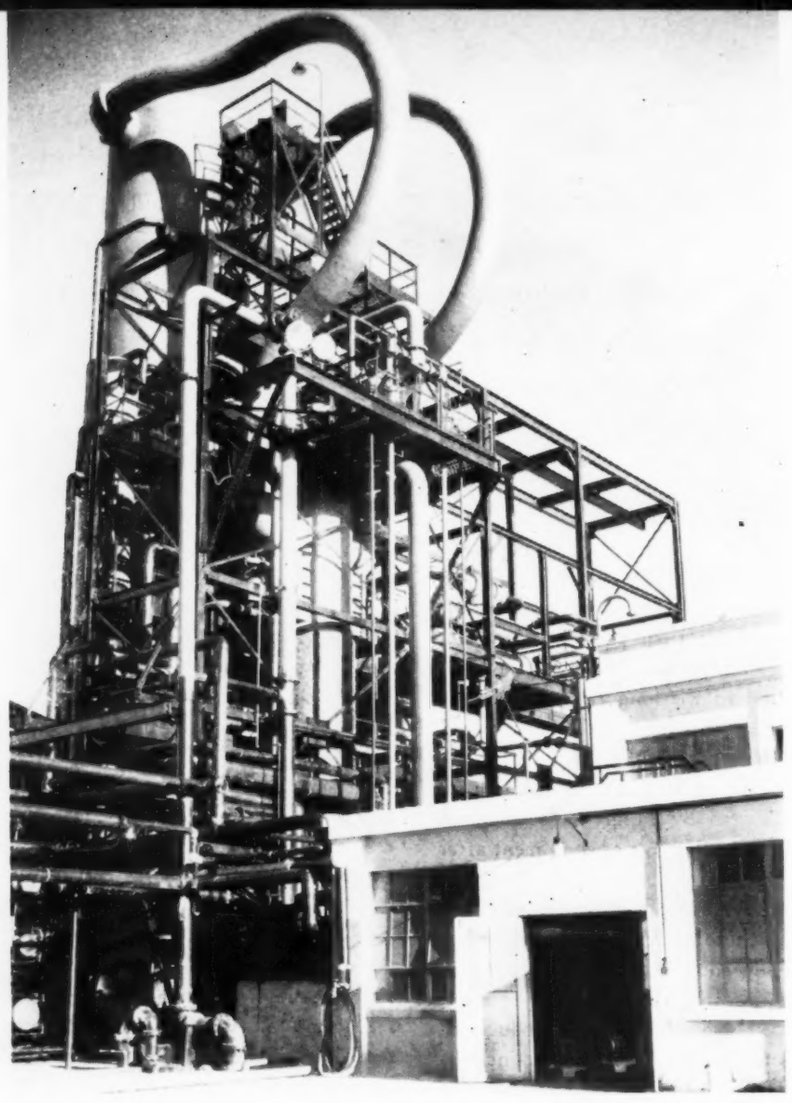
Ultimately there will be an increased demand for oil equipment in the Eastern Hemisphere. Just before the invasion of the Low Countries large orders were about to be placed. These have been canceled and what operations are being continued are performed with the least amount of replacements possible. Those canceled orders will probably be filled eventually, and be augmented by requirements for new development work.

In Europe itself the demand for drilling and production equipment may not be extensive although replacements will certainly have to be made when the war is over. To what extent American equipment will be used for this purpose cannot be foretold. Refineries present a different picture, for the destruction of plants has been widespread and American equipment for replacements will be immediately available for installation.

Another factor in post-war supply must also be considered. While England and the European countries that have previously manufactured oil equipment have been devoting all their facilities to the manufacture of war material, American manufacturers have been improving their designs to meet the demands of efficiency in conducting modern production and refining operations. These advanced designs will be available only from the United States for at least a time after the cessation of hostilities. Moreover, factories geared to make arms and munitions cannot swing into the manufacture of oil tools on a moment's notice, especially with so many other peacetime requirements demanding immediate attention. As in so many things, America must render aid to the rest of the world in the period of reconstruction.

In this situation there is a note of warning. No matter what happens, oil is a necessity of modern life; and the recovery and refining of oil requires equipment. This equipment must be available for use both here and abroad and so-called exigencies must not interfere with its consistent manufacture or advancement in design to meet the ever-changing demands of an industry that is so important to the welfare of a civilized world.

Methods of operation are constantly being improved. Progress in drilling, production, and refining technique necessitates equipment of new design; other new pieces of equipment of special design serve to stimulate the further application of advanced technique and methods. This is true for the petroleum industry in all countries and it is for this reason that a discussion of a number of modern methods is presented in this issue of *The Petroleum Engineer*.



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Vacuum refining tower at La Plata refinery

Petroleum Operations in Argentina

Drilling, producing, and refining activities are closely correlated

By
The Staff of Y.P.F.
(Fiscal Oil Fields)

PETROLEUM ENGINEER EXCLUSIVE FEATURE

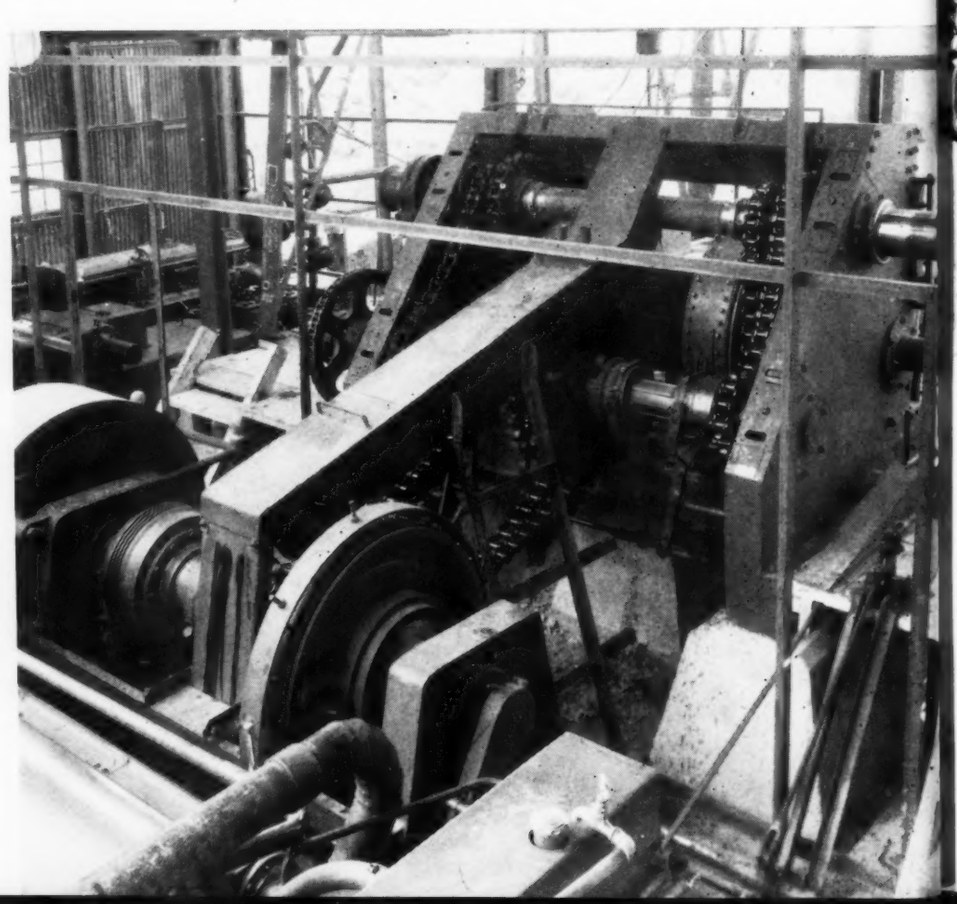
MUCH thought and study has been given to the organization of Fiscal Oil Fields (Y.P.F.) in perfecting a well-integrated operating company that embraces all phases of the oil industry from the preliminary geological and geophysical surveys in search of possible oil beds in the Argentine Republic to the distribution in the country of the products processed in its own refineries from oil extracted from its wells.

The purpose of this article is to describe the methods employed in the various activities of the company.

DRILLING

Drilling equipment. There are 47 of the heavier type rotary drilling rigs and 5 portable rotary rigs now in service in the Argentine. Of the former, 25 are being used at present in exploration and outpost drilling and 22 for development of proved areas and in drilling deep tests. Of the portable equipment two rigs are being used in established fields and three for "slim-hole" drilling in wildcat areas.

Diesel power is used in many drilling operations and it is only at Comodoro Rivadavia that electric power is employed. Electric power is generated in a 24,600-kw. plant situated at



Diesel-powered rotary drilling equipment capable of drilling to 10,000 ft.

Comodoro Rivadavia and is available for nearby drilling. Residue gas from the wells is used as fuel in the engines driving the generators.

Drilling bits. Coring is employed only when oil-saturated sand is expected or when it becomes necessary to determine the depth of a marker. In 1939 an average of 12 percent of the depth was cored in exploratory wells and 5 percent in producing wells.

For soft formations 3- and 4-way bits are used. For hard formations cone and roller rock bits are employed.

Drilling control. While drilling, consideration is given to the weight carried on the bit or core barrel, the pressure of the slush pump, and the number of revolutions of the rotary table. All these factors are carefully controlled, and a record is kept of the drilling time. This information serves principally as a basis for analyzing the service obtained from the bits used.

Drilling procedure. Normally, when the final depth of the wells is reached, an electric log is run to determine the potentialities of the formations. The information obtained from these tests usually agrees closely with the fluid content of the sand formations.

As for the content of the sand formations, that is determined during drilling by means of a formation tester or after pipe has been run and cemented. In most wells the casing is perforated to make the test.

Mud fluid. Special attention is given to the characteristics of the mud fluid by conducting tests as often as conditions make it necessary. The weight is determined by use of a Braun hydrometer, viscosity by means of the Marsh funnel, and the sand content by elutriation. In particular cases the wall-building quality of the mud is tested with a filter press and when deemed necessary the hydrogen-ion concentration is determined.

In areas where clay formations from which the basis mud is made are deficient in necessary qualities, the use of bentonite is relied upon to obtain colloidal substances, barium sulphate to increase the specific gravity, and sodium tannate to decrease the viscosity.

To counteract the high pressure effect of certain water-bearing formations found during drilling, and to neutralize their tendency to flow, it is necessary to use weighting material to obtain a heavy mud. When the volume of water dilutes the mud to the point of danger, precautions are taken to separate as much of the water as possible by settling.

Removal of sand and other inert matter from the mud is done by means of vibrating-screen shale shakers and in some areas by means of centrifugal separators when fine sand, which cannot otherwise be separated from the mud fluid, is present.

Verticality. The angle of inclination of all wells is measured at frequent intervals by means of a clinograph. In deflections exceeding 3 deg. the direction of inclination is also determined. This is done even when such deflection persists such as when the drilling is being done in very pronounced anticlines or in structurally lower formations near the water-oil line.

Depth control. The value of having correct measurements of the depths of drilling wells is fully recognized and every opportunity is taken to check and correct these measurements. For example, a control is established each time a core is taken by the use of wire-line measurement, etc.

Directed drilling. Not all wells are of the vertical type. Controlled directional drilling is frequently utilized, either to reach the oil horizon at a point inaccessible to a vertically drilled well as is the case when the desired location on the sand is under the sea as in Comodoro Rivadavia, or to avoid obstacles such as faulty formations or areas along the coast that are reserved for fishing and in which pollution of the waters must be avoided.

Casing program. The casing used

Central power at Comodoro Rivadavia (left). General view of gasoline plant in same area (right).

TABLE 1
Summary of production methods

Area	Comodoro Rivadavia	Plaza Huincul	Salta	Mendoza	Total
Mechanical pumping	1574	84	7	24	1689
Pneumatic pumping	...	45	44	...	89
Natural and artificial flow	26	18	30	14	88
Total wells	1600	147	81	38	1866

TABLE 2

	Production, Jan.-Aug., 1940		Total production to Aug., 1940		No. of producing wells	Average production per well*	
	cu. m.	bbl.	cu. m.	bbl.		cu. m.	bbl.
Comodoro Rivadavia	881,609	5,545,000	16,718,098	105,153,500	1600	2,861	18,000
Plaza Huincul	75,442	474,500	1,074,060	6,755,500	147	2,154	13,500
Salta	78,372	493,000	418,065	2,629,500	81	6,326	40,000
Mendoza	224,564	1,412,500	415,429	2,613,000	38	37,243	234,500
Total	1,259,987	7,925,000	18,625,652	117,151,500	1866		

*The figures under this heading are derived from individual well records.

is, as a rule, of the A. P. I. type, unjointed, C, D, or J-55 grade. The length of the string, of course, dictates the grade and thickness of the pipe. Likewise the protection provided by the cement encasement in counteracting the hydrostatic pressure of the fluid column in the casing is taken into consideration.

Typical casing programs are as follows:

(1) 500 ft. of 13⅜-in. surface pipe; 3300-4000 ft. of 9⅝-in. casing; 6000-8000 ft. of 7-in. casing.

(2) 1000-1650 ft. of 10¾-in. surface pipe; 5000-8000 ft. of 7-in. casing.

(3) 125-400 ft. of 13⅜-in. surface pipe; 2500-6200 ft. of 7-in. casing.

(4) 250-1000 ft. of 8⅝-in. surface pipe; 2500-5300 ft. of 5½-in. casing.

(5) 2000 ft. of 5½- or 7-in. casing (set without a permanent surface string).

The first three programs are employed in exploration and producing wells; program (4) in "slim-hole" drilling, and the last in production wells located in low-pressure formations.

Cementing practice. Casing jobs, squeeze-cementing, and other cementing operations are done with modern cementing equipment at pressures as high as 3000 lb. per sq. in. When the casing or liner is a full string to the surface it is cemented by the two-plug method but when the cementing job is done behind a section of pipe the operation is performed under pump pressure with the proper cementing equipment for squeezing. This method of cementing is employed not only for placement behind pipe in old wells but also under some circumstances for cementing when pipe has not previously been run.

Well completion. When it is expected that a well will come in flowing, the last string of casing is cemented above the productive zone. When a series of sandy sctions in the same oil formation is penetrated (ordinarily their thickness does not exceed 15 m. or 50 ft.), the casing is cemented above the top productive zone. Then the water, if any, contained in the lower sands is cemented-off and the casing is gun-perforated at the potentially productive zones. If any of the sands contain water, the perforations lying opposite the water-bearing sands are squeeze cemented.

Producing wells are drilled with the intention of exploiting only one oil zone. In exploration wells it is necessary to determine separately the content of each stratum of the various horizons penetrated that have potential productiveness. For this reason each zone is tested independently by means of removable packers. When the producing formations are in open hole below the casing, screened liners are customarily installed.

The method of completing wells by means of gravel packing is being tried, and it is planned to use this process in wells in which the oil sands are unconsolidated.

PRODUCTION

There are producing fields in four general producing areas in Argentina at the present time. These are: Comodoro Rivadavia (National Territory of Chubut); Plaza Huincul (National Territory of Neuquen); the areas of Vespucio, Tranquitas, and Rio Pescado (Province of Salta), and Tupungato and Cacheuta (Province of Mendoza).

The order in which these areas are discussed corresponds to the years in which production was begun in such fields, to-wit: at Comodoro Rivadavia, since 1907, Plaza Huincul, since 1918, at Salta in 1928, and in Mendoza since 1932. The outstanding characteristics of these areas are as follows:

Comodoro Rivadavia. The oil is heavy with only small quantities of solution gas; sand formations are loosely consolidated and have only medium permeability; the wells do not flow and the pressures decline rapidly so that productivity is only fair. Depths vary from 500 to 1500 m. (1600 to 4800 ft.)

TABLE 3
Comparative production in Argentine fields

	January-August				Increase		Percent increase
	1939		1940				
	cu. m.	bbl.	cu. m.	bbl.	cu. m.	bbl.	
Comodoro Rivadavia	870,783	5,477,000	881,609	5,545,000	10,826	68,000	1.2
Plaza Huincul	68,887	433,500	75,442	474,500	6,555	41,000	9.5
Salta	49,614	312,000	78,372	493,000	28,758	181,000	58.0
Mendoza	60,019	377,500	224,564	1,412,500	164,545	1,035,000	274.0
Total (Y.P.F.)	1,049,303	6,600,000	1,259,987	7,925,000	210,684	1,325,000	20.1

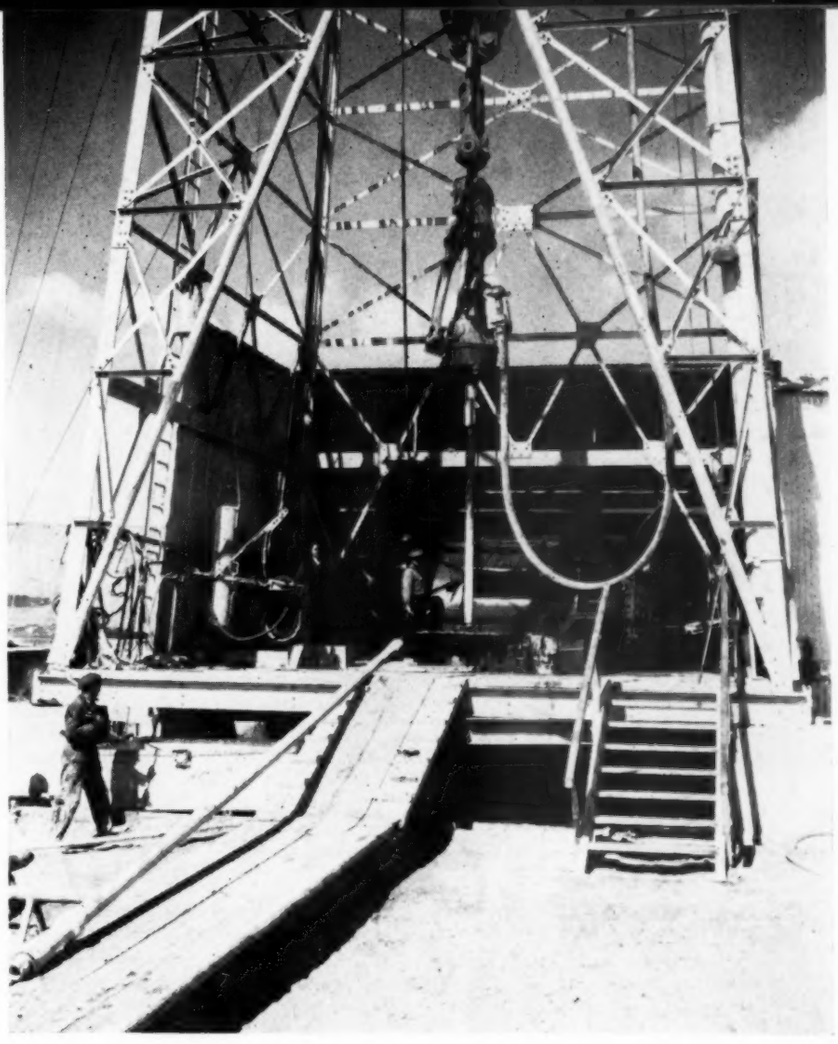
TABLE 4
Characteristics of the crude oil from Comodoro Rivadavia

Characteristics	Medium crude oil			Crude oil from deep formations		
	Percent	Specific gravity	Gravity, deg. A.P.I.	Percent	Specific gravity	Gravity, deg. A.P.I.
Density of crude oil		0.916	23.0		0.887	28.0
Gravity of crude oil, deg. A.P.I.						
Naphtha	7.4	0.7428	59.0	11.37	0.737	60.5
Kerosine	5.05	0.802	45.0	12.84	0.790	47.6
Gas-oil	12.35	0.845	36.0	7.90	0.833	38.3
Light lubricants	7.2			13.51		
Medium lubricants	16.98			3.99		
Heavy lubricants	14.23			7.85		
Residue	32.73			42.04		
Water and sediments	3.5					
Pour point, °C	Under zero			Minus 5		

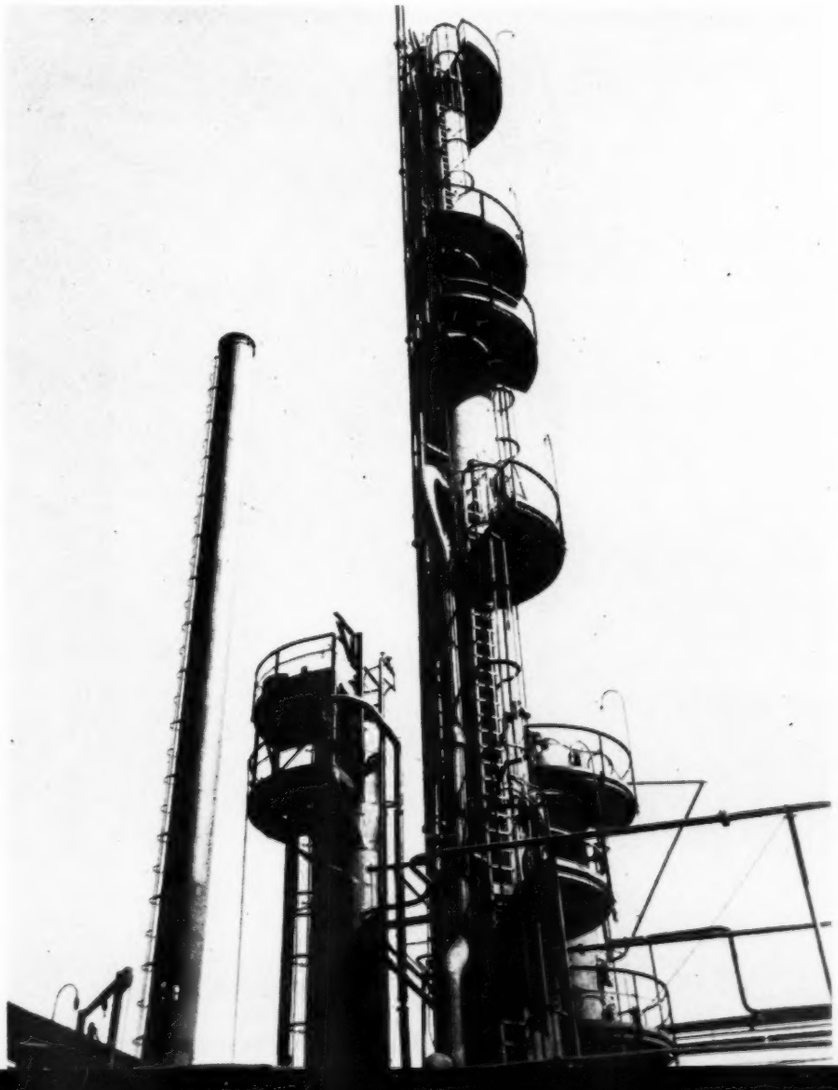
Plaza Huincul. The oil is relatively high in gravity and there are several gas zones. Sand formations are fairly consistent. The productivity indexes of the wells are low and, although the wells flow for a time, pressures decline rapidly and the wells must be pumped. Depths of the wells are from 600 to 800 m. (1900 to 2600 ft.)

Salta. The oil in this area is also rather high in gravity and has a rather large quantity of dissolved gas. The sand formations are not very consistent — fine sand and minor density. The wells flow with a low productivity index, and the gas extracted from the wells is returned to the formation in a pressure-maintenance program. Depths of wells are from 600 to 1500 m. (1900 to 4800 ft.)

Mendoza. The wells at Tupungato are flowing and are fairly large producers of high-gravity oil with little gas. The sand formations are uniformly "light" although being fissured. There is evidence that a water drive exists that is resulting in pressures declining very slowly. Well depths are approximately 2200 m. (6800 ft.)



Drilling to 7500 ft. is easily accomplished with this up-to-date drilling equipment



Fractionating tower at the La Plata refinery

In Cacheuta there is light oil with little gas, medium consistency in sand formations of minor density, small production non-flowing wells, declining pressures, and depths from 600 to 1000 m. (1900 to 3200 ft.)

Production Methods

Of the number of wells now producing only a few are of the natural flowing type. Artificial production methods are employed on the other wells. Predominating among such methods is the mechanical pumping system, with various gas-lift systems and pneumatic pumps used to a limited extent. Table 1, for the month of August, 1940, lists these methods and systems.

In the Comodoro Rivadavia fields (National Territory of Chubut), where the wells have a relatively low formation pressure considering their depths, the oil has a gravity of 22.5 deg. A.P.I. (s.g. 0.925) and contains little dissolved gas. As production con-

An extensive system of elevated roadways connects off-shore producing wells in the Comodoro Rivadavia fields

tinues, considerable quantities of water appear and it thus becomes necessary to place nearly all wells on the pump.

Wells with depths of 800 m. (2500 ft.) and very limited production are pumped by means of central pumping stations in groups of 15 to 20, according to the local conditions of the terrain. There are now in operation a number of central powers of the old band-wheel type but for the last eight years the geared-type central power has been adopted, because of its technical improvements.

For wells of greater depths situated in more productive areas, modern individual pumping units with geared speed reducers and rotating counterweights are employed. The few standard rigs still in service are being modernized with reducers and other parts.

Similar conditions prevail in the fields of Plaza Huincul (National Territory of Neuquen); in areas of Encampments Nos. 2 and 3, respectively, (in the Province of Mendoza); in the area of Cacheuta; and in the Province of Salta (areas of Encampment Vespucio).

Power for the operation of pumping equipment is supplied entirely by electric motors at Comodoro Rivadavia, electric motors and gas engines at Plaza Huincul, and Diesel engines at Mendoza and Salta.

In recent years pump barrels of the

The plant at La Plata is the principal refining unit of Y.P.F. and likely will remain so, although other refineries have been built to give geographical distribution

insertable type have been placed in operation and are giving satisfactory service. Likewise the casing pump is being used successfully on some wells at Comodoro Rivadavia. These pumps are used together with long-stroke pumps to extract large amounts of water. Thus the old swabbing method, expensive and inadequate, formerly used on such wells, has been abandoned.

The pneumatic pumping method is employed at Encampment No. 1 in Plaza Huincul and in the Tranquitas (Province of Salta) area. Control of the periodical gas injection is generally effected by hand, although the few clock valves that have been installed operate satisfactorily.

Pneumatic pumping is applied to wells of small production, from approximate depths of 700 m. (2300 ft.). In some of the larger producing wells in the Tranquitas area the gas-lift method, with continuous gas pressure injection, is employed. In the future, when the natural flow may decline or cease in the other wells of this area, and in order to conserve the volume of injected gas required, it is planned to install intermitters and automatic flow valves in the wells.

In all newly developed areas, even in those where wells are on the pump, the extracted gas is being injected for the purpose of maintaining formation pressure. Thus far it is not possible to ascertain definitely the advantages derived by this method, but no great success is expected. Likewise, production from all new areas is being restricted, in order to obtain a more uniform production from all wells. This program is being guided by a systematic plan of obtaining measurements of pertinent factors using up-to-date recording instruments.

Determination of the proper gas-oil ratio has been made in many wells recently on the basis of analyses of deep oil samples, for which a Humble "closed chamber" sampler and a Stupakoff "open chamber" sampler are being used. Likewise, it has been decided to install modern laboratories for the analysis of cores with the view of ascertaining as definitely as possible the value of the oil reserves in the ground and to prepare for secondary recovery methods.

Present production status. Table 2 shows the present production in the various oil fields and the number of producing wells.

Comparing the data given in Table 2 to a similar period for the previous year, an increase in production until August of this year is shown in Table 3.

Although the increase in production in the Comodoro Rivadavia and Plaza Huincul fields is comparatively small, it is, nevertheless, significant when it is realized that this yield comes from oil fields that have been producing for 33 and 22 years, respectively.

The increase from the Salta area reflects the development of new production at Tranquitas since the beginning of the year, and the more recent development that has placed the Rio Pescado field among the regular producing areas.

The fourfold increase in production from the Mendoza area is the result of the extraordinary productiveness of the wells at Tupungato, which flow naturally in an uninterrupted production schedule.

REFINING

The refining activities of the Y.P.F. date from the initial operation in 1925 of the refinery at La Plata, the first of several plants that are now operating. During the 15 years' refining experience, the continuous progress made has surpassed all earlier expectations.

The refining capacity of Y.P.F. in 1925 was 2800 cu. m. (17,600 bbl.) of crude oil per day. With the installation and beginning of operation of the new refineries at Lujan de Cuyo and Salta, the total daily capacity in 1940 will be 7900 cu. m. (50,000 bbl.). The daily cracking capacity in 1926 was only 320 cu. m. (2000 bbl.) of gas oil. Cracking capacity at the present time is 6525 cu. m. (41,000 bbl.) a day, of which 5385 cu. m. (34,000 bbl.) is employed in cracking reduced crude, and 1140 cu. m. (7200 bbl.) is devoted to cracking gas oil in cracking units installed in the La Plata refinery prior to 1934.

The development of oil processing by Y.P.F. has kept pace with the demands for refined products in the Argentine Republic. In 1929, only three years after the La Plata refinery began operations, it was found necessary to increase the capacity by installing an additional unit for producing more fuel and a cracking unit to reduce gas oil and thus increase the naphtha and light fuel production.

After several years of work in the laboratories and in semi-industrial plants, Y.P.F. established what is believed to be the most economical method for the manufacture of lubricating oils, using crude oil from Comodoro Rivadavia. The characteristics of this crude are given in Table 4. In 1933 there was installed in the refinery a vacuum and steam refining unit having a capacity for processing 350 cu. m. (2200 bbl.) of reduced

TABLE 5
Production in the La Plata Refinery from 1926 to 1939
(Volumes are corrected to 15°C.)

Year	Motor fuel		Aviation fuel, industrial naphtha, benzol		Kerosine and farm distillate		Methanol		Fuel oil and Diesel fuel		Lubricants, paraffins, greases, and petrolatum		Asphalt		Supergas		Insecticide		Total throughput	
	cu. m.	bbl.	cu. m.	bbl.	cu. m.	bbl.	cu. m.	bbl.	cu. m.	bbl.	cu. m.	bbl.	cu. m.	bbl.	cu. m.	bbl.	cu. m.	bbl.	cu. m.	bbl.
1926	41,159	258,900	186	1,170	24,732	155,600	.....	.....	456,430	2,871,000	.....	.....	.....	.....	.....	.....	.....	.....	547,185	3,442,000
1927	67,547	424,900	.....	.....	30,663	192,900	.....	.....	604,663	3,803,000	.....	.....	.....	.....	.....	.....	.....	.....	713,062	4,485,000
1928	81,907	514,500	916	5,760	32,403	203,800	.....	.....	647,258	4,071,000	.....	.....	.....	.....	.....	.....	.....	.....	784,415	4,934,000
1929	115,877	728,800	1,322	8,320	30,524	192,000	.....	.....	533,828	3,358,000	.....	.....	.....	.....	.....	.....	.....	.....	717,939	4,516,000
1930	145,405	933,400	2,343	14,740	41,124	258,700	.....	.....	521,954	3,283,000	.....	.....	.....	.....	.....	.....	.....	.....	769,861	4,842,000
1931	162,691	1,024,600	2,712	17,060	41,867	263,300	.....	.....	541,229	3,404,000	.....	.....	.....	.....	.....	.....	.....	.....	805,764	5,068,000
1932	199,720	1,256,200	2,465	15,500	41,612	261,730	.....	.....	567,043	3,567,000	.....	.....	.....	.....	.....	.....	145	912	863,197	5,429,000
1933	169,169	1,064,000	3,600	22,640	38,585	242,700	403	2,535	564,185	3,549,000	1,032	6,490	.....	.....	146	918	324	2,040	811,785	5,106,000
1934	150,421	946,100	7,037	44,260	45,691	287,400	75	472	565,437	3,556,000	9,120	57,360	1,019	6,410	1,226	7,710	133	837	801,803	5,043,000
1935	179,525	1,085,100	10,521	66,170	49,816	313,300	110	692	584,974	3,679,000	9,014	56,700	3,962	24,920	2,443	15,370	129	811	862,049	5,422,000
1936	216,263	1,360,300	9,751	61,330	64,862	408,000	103	648	730,777	4,596,000	10,664	63,300	7,013	44,110	3,924	24,680	186	1,170	1,051,635	6,615,000
1937	233,266	1,467,200	12,029	75,660	74,048	465,700	156	981	721,849	4,539,000	14,406	90,610	13,901	87,410	5,839	36,720	163	1,025	1,077,231	6,776,000
1938	242,443	1,524,900	14,473	91,030	74,903	471,100	160	1,010	743,309	4,675,000	15,913	119,000	13,913	87,510	7,627	47,970	112	704	1,123,287	7,065,000
1939	238,184	1,498,100	20,824	131,000	60,873	439,500	166	1,040	649,366	4,084,000	24,426	153,600	24,594	154,700	9,250	58,180	299	1,880	1,053,715	6,628,000

crude oil. The stocks obtained from this plant are treated with SO_2 in an Edeleanu plant having a 160 cu. m. (1000 bbl.) daily capacity. The refined oil is treated with acid in centrifugal machines and contacted with clay. The paraffin from the treated heavy oil is separated by means of centrifugal machines and is then re-refined. The wax content of the light oils is separated by means of filter presses and a second refining.

The production of lubricants by Y.P.F. in 1933 was 1032 cu. m. (6500 bbl.) and at the present time the annual production is 23,591 cu. m. (148,000 bbl.)

The refinery at La Plata has a daily crude capacity of 5000 cu. m. (31,500 bbl.) In this plant there is a complete combined topping unit, cracking, polymerization, and steam naphtha equipment. It produces from the Rivadavia crude 250,000 cu. m. (1,572,000 bbl.) of gasoline per year. This gasoline has an octane rating of 69.

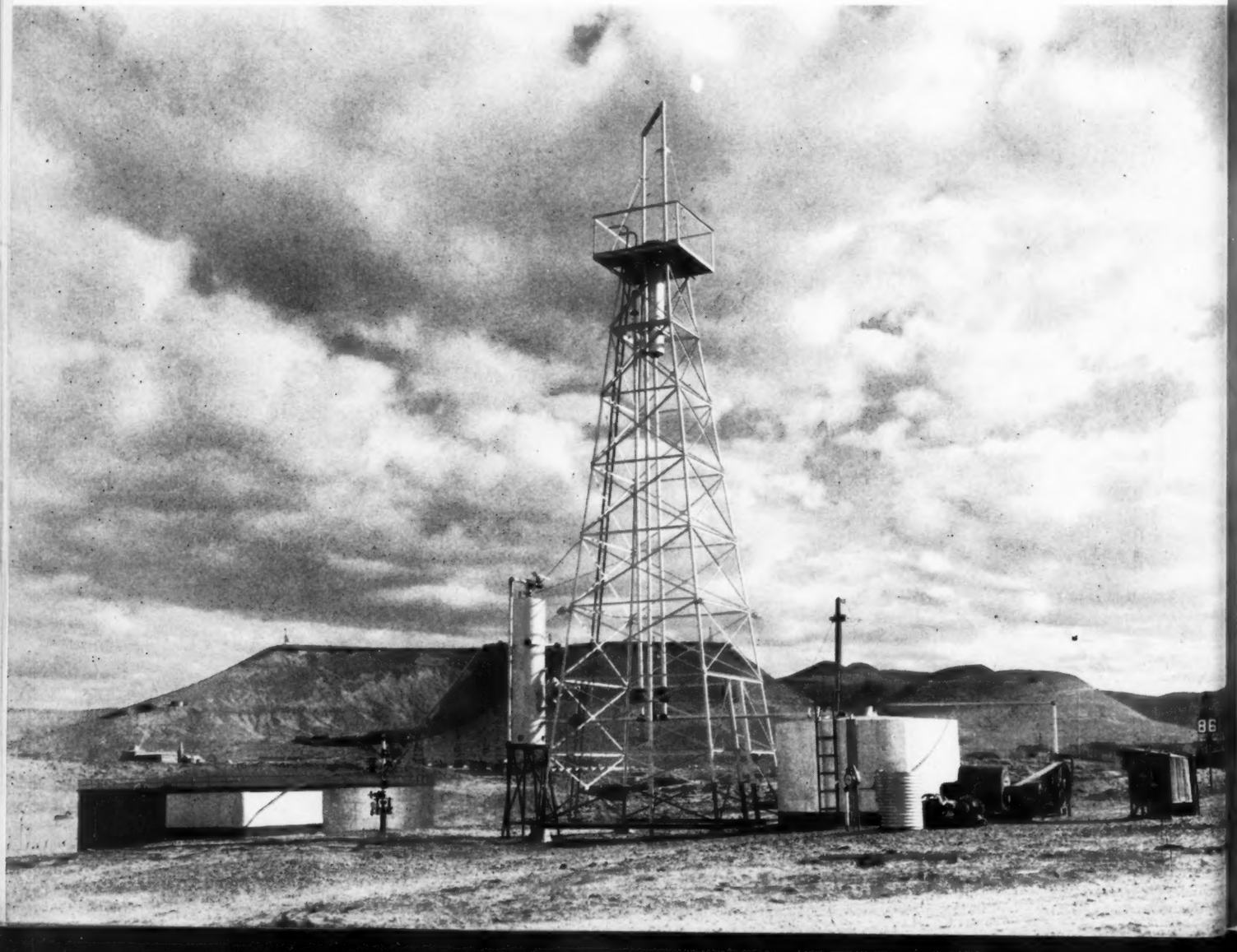
Following the plan of better supplying the needs of Argentina for refined products from oil produced in the country by decentralizing the processing of crude, Y.P.F. in 1938 installed in the province of Santa Fe, in the San Lorenzo region, where the north and south roads of the country converge, a refinery with a manufacturing capacity of 1500 cu. m. (9500 bbl.) per day of crude oil. The refinery is equipped with a combined unit including topping, cracking, polymerization, and processing units for all types of fuels.

Likewise, in view of the increased production from the Y.P.F. fields in the north, a refinery with a daily capacity of 300 cu. m. (1900 bbl.) of crude oil is being installed at Salta and will obtain its supply from wells in the Province of Salta. This refinery is equipped with a combined unit—topping, cracking, and reforming. It is expected that this plant will begin operations the latter part of this year, and its production will be sufficiently large to supply the fuel needs in the northern part of the country.

The importance of the production from the Tupungato field, Province of Mendoza, prompted Y.P.F. to install at Lujan de Cuyo a refinery with a combined topping and cracking unit having 500 cu. m. (3150 bbl.) capacity, which is sufficient to supply the fuel needs in the area known as the region of Cuyo formed by the provinces in the central west section of the country.

In view of the scarcity of solid fuels (coal, wood, etc.) in Argentina and because the most populated areas in the country are so far removed from the oil and natural gas fields, Y.P.F., in 1932, began the manufacture of liquefied gases from the gas extracted at its refinery in La Plata. At the present time the annual production of supergas, or liquefied petroleum gas, is 9250 cu. m. (58,000 bbl.). In 1934 the volume produced was only 1019 cu. m. (6400 bbl.). This year production of supergas has been started in the San Lorenzo refinery.

A flowing well at Comodoro Rivadavia with separator installation and storage tanks



Primary and Secondary Recovery Methods Increase Yield from Producing Properties

Gas-repressuring is being applied in many smaller fields—waterflood is successful method but there is dearth of properties that may be profitably exploited

By H. LEE FLOOD, Associate Editor

ALTHOUGH there is still a certain amount of confusion in the terminology of recovery methods, the word "secondary" has come to be understood generally to apply to those methods that are employed during the latter life of a field to supplement the normal production methods usually employed.

When methods similar to those termed "secondary" began to be applied in the early stages of a field's life, representing more or less immediate efforts to obtain greater ultimate recovery, a certain amount of confusion and misunderstanding arose and it was suggested that the term "primary" be used to describe these early recovery programs to differentiate them from the truly secondary applications.

The term "primary" has appeared more often during the last year but even it has proved confusing, inasmuch as so many field engineers and others think of natural flow, gas lift, and pumping as being primary recovery methods when actually it is not intended that the word "primary" as proposed should include these methods at all.

As generally understood by many engineers, there are now three broad classifications used to designate the various types of recovery methods: normal, primary, and secondary. Although it is difficult to prescribe definite lines of demarcation between these terms, there are certain distinguishing general features that may be outlined.

Normal Recovery Methods

Normal recovery methods are usually considered as including all the devices and measures that may be employed to obtain as much oil or gas from a formation as possible without resorting to any artificial method of replacing, displacing, or augmenting the natural contents of the reservoir. These methods include, of course, natural flow, gas lift, and pumping. Although gas lift is usually an artificial method of lifting, its principal effect is confined to the wellbore and hence does not influence the relationship of gases and fluids within the formation. Classed properly as a part of normal recovery methods should be all types of work done to augment the normal yield or to increase the efficiency of normal production. Control of gas-oil ratios, both in natural flow and in gas-lift operation, would be a part of efficient normal production practice. Likewise, acidizing, shooting, cleanout work, squeeze-cementing and other methods of reducing gas-oil ratios or water production, studies and controls employed to control coning and to otherwise obtain the maximum benefit from natural drive—all these and other similar expedients that are now employed by production engineers to increase the efficiency of natural production are considered to be ramifications of normal recovery technique and should not be thought of as primary recovery methods, under the accepted sense of the latter term.

Primary Recovery Methods

Primary recovery methods embrace all methods that may be instituted during the early life of a field to increase the total amount of oil recovered from the reservoir above the volume that would be yielded if only

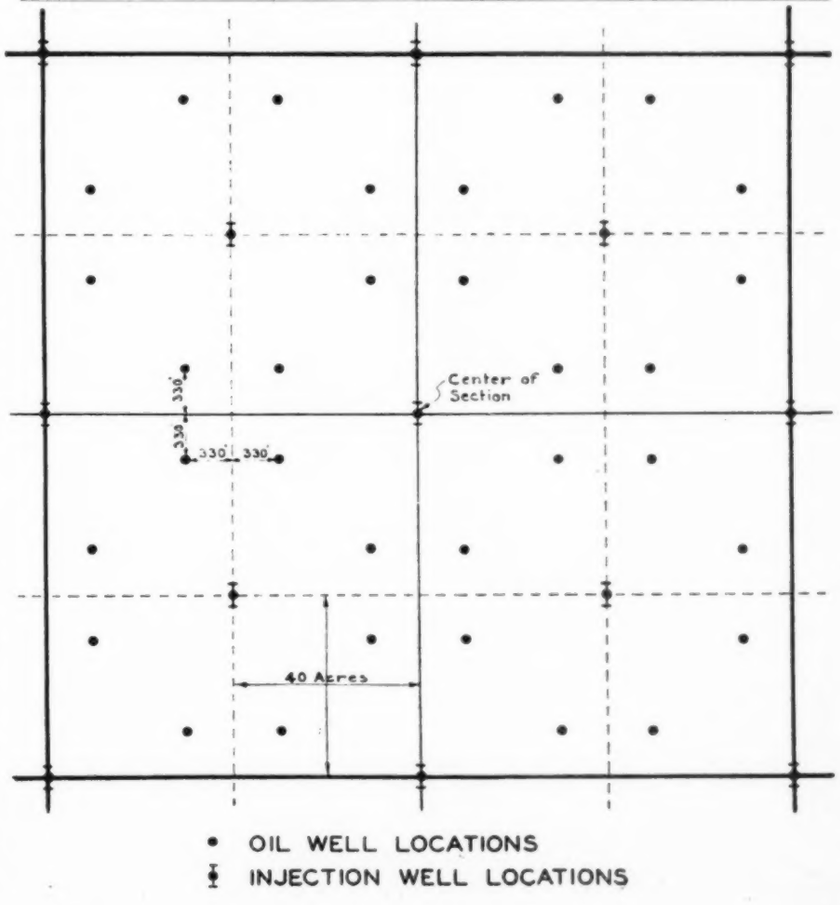


Fig. 1. Detail of sunflower spacing pattern. Oil-well density, 1 per 20 acres; injection-well density, 1 per 80 acres *(after R. J. Sullivan)*

normal recovery methods had been employed. One of the outstanding examples of a field in which a primary recovery method is being applied is the Loudon pool in Illinois. With only a few exceptions, all the wells in this field have been drilled in accordance with the so-called "sunflower" pattern of well spacing, as illustrated in Fig 1. Spaced in this manner, the edge wells in each pattern serve as producing wells and the center wells are utilized as input wells for the return of gas to the formations. From an engineering standpoint, the plan is to return gas through the central wells of each pattern at such a controlled rate and pressure as to establish a gradient from the center well outward that will cause the injected gas to drive the oil ahead of it and result in a more efficient removal of the oil contained in the interstices of the sandstone.

Other than programs in which gas is returned to the formation in the early stage of production, as at Loudon, all attempts to establish water-flooding or to create an artificial water drive in the early life of the field would properly be included as primary recovery methods.

The question arises as to how recycling operations in connection with the production of condensate should be classified. This practice involves return of gas to the formation during the earlier life of a field and thus as a distinct form of pressure maintenance should probably be classed as a primary recovery method. Yet because the return of gas in gas-condensate fields is now recognized as a prime essential in efficient recovery from reservoirs of this type, recycling might well be classed as a normal recovery method in this type of production. Because the problems involved in recycling are of such special application to distillate recovery alone, it is believed less confusion will result if recycling is considered separately.

Secondary Recovery Methods

Having made the above classification, secondary recovery methods may now be considered as comprising all methods of stimulating normal recovery that are applied in the latter stages of the life of a field. The best known types of secondary recovery methods are, of course, water-flooding and gas repressuring.

If the principal distinction between primary and secondary recovery methods is apparently one of time of application, as has been intimated, one may question how long a recovery program may be postponed and still be classed as a primary method and, conversely, how much time must elapse before attempts to augment recovery may be termed secondary. The matter of time of instituting the recovery plan does enter into the choice of terms but more important is the consideration of how far the reservoir pressure has been permitted to decline and of other factors that pertain to the manner in which the field has been produced.

Current Developments in Recovery Methods

Interest on the Gulf Coast and in other areas of Louisiana and Texas in recycling and distillate-processing plants has more or less overshadowed other types of recovery projects involving the return of gas underground. It is known, however, that permission has been granted by the Railroad Commission of Texas in numerous instances to companies who desire to install repressuring equipment on their producing properties. In most of these cases, the leases involved are in small fields and do not excite much interest. The fact that so many small repressuring projects are in operation is indicative, however, of the increased acceptance that is being accorded primary and secondary recovery methods.

Perhaps the predominant trend during recent months in all types of projects involving production-stimulating methods has been to recognize more fully the importance of adequate production records and particularly of data pertaining to the characteristics of the producing formations. Well logs are essential as a basis for determining the continuity or areal extent of a given formation. In many existing projects, failure to note any material effect on either pressure or yield has often been due to the presence of lenticular sections that are entirely disconnected from well to well.

Although it is not generally recognized, water-flooding at the present time is at the crossroads. This does not imply that water-flooding is not a successful method of further exploiting the older oil reserves of the country, but it does mean that there are very few undeveloped properties (from the standpoint of water-flooding development) in sight that possess the elements necessary for profitable operation of a water-flooding project.

It is generally recognized now that the most important step in evaluating the water-flood possibilities of a specific producing property is to procure adequate data on the sand thickness and characteristics and the only reliable way in which this information can be obtained is by adequate core analyses. One of the best informal treatises on the elements that determine whether a water flood will be profitable appeared earlier in the year.[1] It is significant that much of the discussion pertains to the information to be derived from intelligent core analyses.

Aside from repressuring and water-flooding, there have been no important methods of secondary recovery that have really come into the picture. It is of passing interest to note that the successful drilling of a horizontal well[2] in Ohio has stimulated plans to drill several horizontal wells in the Appalachian area as a method of further exploiting depleted oil sands.

In most cases the desired results will be obtained through the use of both a mining operation and horizontal drilling, and the method currently receiving the most consideration may be outlined as follows:

A thorough study of the producing formation will be made and a shaft will be located on the lower part of the structure, and, before beginning mining operations, the area in the immediate vicinity of the shaft will be pregrouted with cement in order that the shaft may be sunk without interference from surface waters. In sinking the shaft a drop shaft would first be placed through the upper formations subject to caving and then mining operations continued, as before, to the producing horizon. On completion of the shaft, horizontal drilling equipment can be installed, a horizonal hole drilled into the pay section, with drilling so controlled that the closed end of the drill hole, when completed, will be higher than the point which penetrated the sand, thus permitting the oil to flow by gravity to the shaft without the benefit of formation pressure. This shaft may be utilized in drilling and producing any number of radial holes desired.[3]

Summary

It would be impossible in the limited space available to describe in detail the many studies and advances being made in connection with the application of recovery methods. The most important point to be stressed is that adequate records should be kept of every well, including logs, cores, pressures, and production data from the time the discovery well is drilled, through to the end of the productive life of the field. Failure to assemble these vital statistics may easily spell the difference between a successful, profitable recovery program and one that fails completely because of too many unknown factors.

[1] "Factors that Determine Profitable Secondary Recovery" by Ralph T. Zook, *The Petroleum Engineer*, March, 1940.
[2] "The First Horizontal Oil Well" by Leo Ranney, *The Petroleum Engineer*, June, 1939.
[3] "Report of Eastern District Topical Committee on Drilling Practice, read at Tenth Mid-Year Meeting of the A.P.I., Fort Worth, Texas, May 27-31, 1940.

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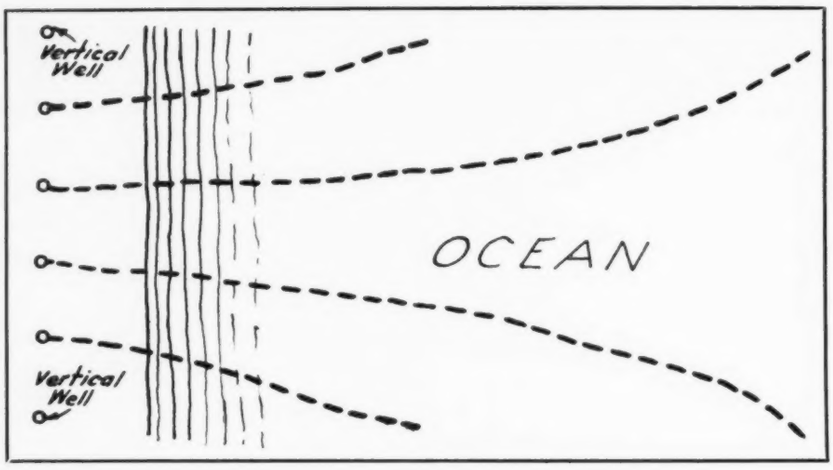

Fig. 1. Illustrating the manner in which one company obtained spacing on the sand beneath the ocean, drilling from a shore location

Directional Drilling to Overcome Surface and Subsurface Obstacles Has Application In Fields All Over the World

Ability to point drill at any angle and control its progress has solved the problem of inaccessibility in many foreign operations

By WALLACE A. SAWDON
Pacific Coast and Foreign Editor

ALTHOUGH the more spectacular applications of directional drilling, as exemplified by killing a burning well through a directionally drilled offset or tapping a sand beneath the ocean from a shore location, call attention to the accuracy with which the underground course of a well may be controlled, the consistently reliable results being obtained by means of directional drilling and the economies derived from its use under many conditions are probably not fully appreciated. Controlled directional drilling is being practiced to some extent in all parts of the world; and with equipment now being operated under the supervision of company engineers the economic advantages offered by directional drilling are being more widely utilized in many countries.

Controlled directional drilling or, as it is sometimes called, "slant hole" drilling, provides the means of reaching a productive zone at a predetermined point some distance horizontally from the surface location of the well. It is employed for two general purposes: (1) for drilling new wells that cannot be located directly above the desired completion point on the productive zone because of economic, topographical, or structural conditions, and (2) for reconditioning or bringing back to production old wells by abandoning a portion of the hole and deflecting it to a different position in the producing zone. Old wells are also deepened to lower zones at points horizontally distant from the original bottom by directional-drilling methods. More specifically, the problems met by controlled directional drilling are as follows:

Locations beneath water. When a well is to be completed beneath the ocean it is now the more general practice to drill from a shore location as at Huntington Beach, California, where spacing on the sand is obtained by one company as shown in Fig. 1. At other places along the Pacific Coast where piers for ocean drilling have been built, the piling structures are frequently utilized for multiple-hole operations. As illustrated in Fig. 2, one derrick location with provisions for skidding the short distance necessary to drill three holes in triangular location only 3 to 4 ft. apart at the surface, was used to save the expense of constructing more pier.

At Comodoro Rivadavia in Argentina a number of rows of vertical wells have been drilled on semi-submerged land that is exposed by the tides for several hours each day. From the last line of these wells other wells are directionally drilled to locations under the Gulf of San Jorge where the sea bed is deep and high tides often reach the proportion of severe storms. Similar problems have been overcome in other parts of the world; a number of wells have been directionally drilled beneath the China Sea. Rivers and channels where obstructions cannot be permitted to interfere with navigation often necessitate directional drilling from shore locations even though the cost of operating from the surface of the water might not be prohibitive. Such a condition obtains along the Irrawaddy River in Burma.

Inaccessible locations. The value of directional drilling for spacing of wells in subsurface formations below buildings and other man-made obstructions has long been recognized; but it is doubtful if full advantage has been taken from an economic standpoint of utilizing the means of drilling to overcome topographical conditions. Mountainous country, swamplands, and similar inaccessible areas frequently require expensive road

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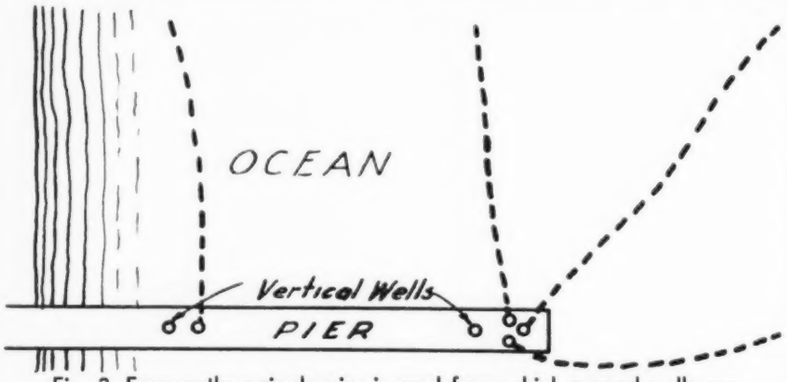


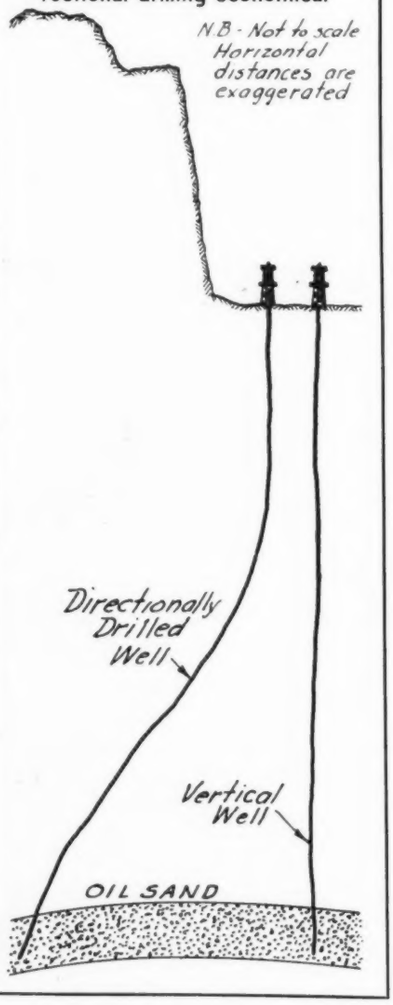
Fig. 2. Frequently a single pier is used from which several wells are drilled into the ocean

work, excavations, and costly preparations for the arrangement of surface equipment at the point vertically above the desired location in the sand. A little thought and study may prove that the operation is near enough to a more desirable site from which a well can be drilled directionally at much less expense. In many cases one such location can also be used to advantage for the drilling of more than one well, with considerable savings for each operation.

Structural conditions. Directional drilling to exploit the flanks of salt domes is confined principally at present to the Gulf Coast area of the United States and to certain fields in Germany. Considerable trouble and expense have been avoided in drilling adjacent to some of these domes by drilling around badly fissured and broken cap rock above the salt, in avoiding heaving shale zones, and even in eliminating drilling the salt itself. Other structural conditions that present hazards while drilling can sometimes be overcome when faults or other unconformities offer a means of passing them up by locating the well at a different point on the surface and deflecting into the producing zone. Edge wells, especially those used to determine the productive area of a field, can often be plugged-back and deflected to a point higher on the structure. Formations cut off by minor faults can be reached in a similar manner and wells drilled to test the "other" side of a fault can be deflected across the fault if the test is non-productive. Wells drilled off structure can be salvaged in many instances by following this procedure.

Multiple-hole exploration with wells drilled from one location, usually by skidding the derrick a few feet, has not been practiced to the extent that many adverse surface conditions would seem to warrant. Test holes can be deflected over a considerable horizontal area and, the exact location of the bottom being accurately determined by directional drilling records, correlation with geological and geophysical data might often prove of particular value in remote areas where intensive exploratory work is being done.

Fig. 3. Topographical conditions such as here indicated often make the use of controlled directional drilling economical



Remedial work. Depleted wells and those in which sand conditions around the well bore have restricted production can frequently be plugged for some distance and deflected into the sand at a better location. Remedial work, however, quite often has to be done with drilling wells, even with wells being directionally drilled as has been the case at Comodoro Rivadavia where, in one instance, a well directed beneath the ocean ended up on the wrong side of a fault that swung farther than expected. By merely plugging-back and deflecting to a new predetermined location across the fault the well was completed with little additional trouble. In drilling vertical hole where the bore is allowed to drift too far, directional drilling methods sometimes are employed to bring the hole back to its proper course. Although lease limits seldom have to be considered in many countries because of extensive concession areas, keeping the well within certain boundaries frequently necessitates the use of directional drilling in the United States.

The use of directional drilling to complete a hole close enough to another well that has cratered in order to kill the cratered well through the new hole has been widely publicized. With present control equipment and methods there will probably be less cratering of wells and it is hoped that this application of directional drilling will never again be necessary.

Methods and Equipment

Whipstocks are used almost exclusively for changing angle and direction (except with slight changes that can be made without mechanical means) and single-shot instruments recording both angle of inclination and horizontal direction are employed to guide the work. The survey instrument is run periodically to check the course of the hole and to indicate the inclination and direction necessary for any desired change.

When a change in the angle and direction is necessary to keep the well on its predetermined course, the whipstock is oriented into the hole to set at a position determined from the single-shot reading. This causes the bit to start off in the direction desired. By proper procedure all dog-legs in the hole are avoided and in a hole put down by controlled directional drilling there should be no more trouble in running casing or in going in and out of the well than in the average vertically drilled well.

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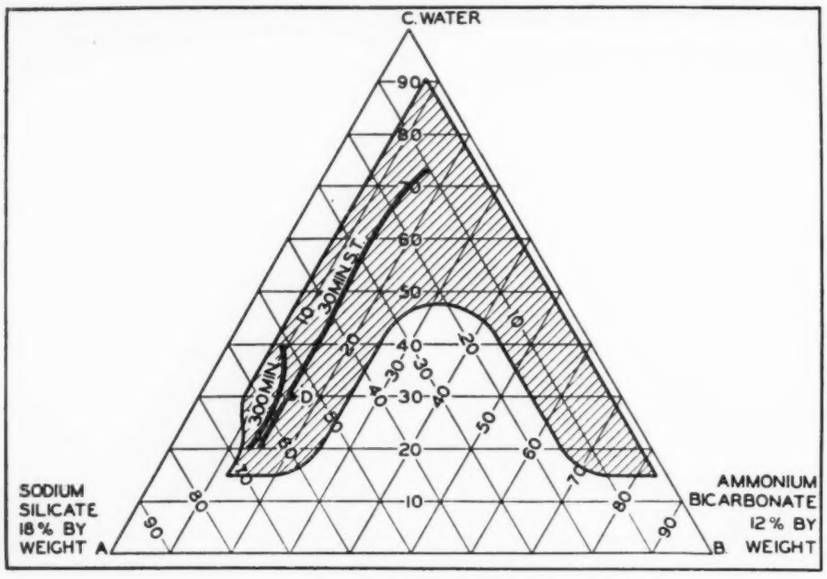

Fig. 1. Graph showing zone of solidification of three-component plugging solution *(after P. E. Fitzgerald)*

By
H. LEE FLOOD
Associate Editor

Current Developments in the Use of Acids And Other Chemicals in Oil Production Problems

Application of chemicals to production problems promises to be outstanding forward step in obtaining greater ultimate recovery from reservoirs

THE refining of petroleum from its very inception has been the special province of the chemical engineer but it is only within recent years that the chemist with his ability to perform what often seem miracles has pervaded the drilling and producing branches of the industry. In fact, it was not until after the first successful treatments in 1932[1] of limestone and dolomite formations with inhibited hydrochloric acid "that the possibilities of chemical treatments of other kinds have been appreciated."[2]

In the last eight years, the development of new uses and applications for chemicals in drilling and production problems has gained momentum so rapidly and is proceeding currently in so many different quarters that it is only with difficulty that one may keep abreast of the progress being made.

In drilling operations, use of chemicals has been confined almost entirely to treatment of drilling muds but the subject has rapidly become so complicated and specialized that a complete record of all that has been learned and of the additional knowledge that is being gained every day would occupy several volumes. It is no overstatement to say that the growth in knowledge about drilling mud has been phenomenal in the last five years.[3]

In the space available, however, it will be possible to do little more than discuss some of the recent applications of chemicals to production problems and even then thorough treatment will be out of the question. Exhaustive study of each development should include the whys and wherefores of the chemical reactions involved, but as the average production engineer is not a chemist, his interest is more in the results obtained and the effect they have on his problems.

Surveying briefly the production problems of principal interest at the present time in which chemistry is playing a leading role, we find that the pioneer of them all, the acid treatment of wells, in all its phases, still commands the greatest amount of attention. Probably the next most important development from the standpoint of benefit to the producer is the use of chemical substances as plugging agents to control or exclude water, that bane and bugaboo of the production man's existence. Also, dealing with water, but offering an entirely different means of keeping it under control are the distinctly new chemicals that exhibit the ability to reduce the surface tension of water and thus inhibit the tendency of this liquid to displace oil in the pores of the reservoir rock. Of minor relative importance, perhaps, but a boon to the production engineer when temporary plugs are required, are the various cements and chemical mixtures that are now available as plugging or sealing agencies. Of greater importance than is often realized is the progress being made in developing a satisfactory solution to the problem of dissolving paraffin in producing wells.

Acidizing Developments

Although rotary mud is the driller's friend, it can often prove a headache to the producing department. Particularly in the drilling of low-pressure sands, but also troublesome even in high-pressure formations, the pores of the rock may become so congested with mud and/or water pressed from the mud that it is often only with difficulty that the well may be cleaned-up and the flow of oil induced.

This problem of demudding sand formations has been the subject of much research and development work. At the present time the method proving most successful involves the use of a new acid that is very reactive to silicates as well as carbonates but is non-reactive on iron and most other metals used in oil-well equipment.

Very satisfactory results have been obtained with this new mud acid on the Gulf Coast of Louisiana in cleaning-up formations by removing the drilling mud completely, using 1000 gal. of acid for each 10 to 15 ft. of exposed oil-bearing sand, half of which may be mud acid and the rest composed of a chemical wash solution.[4]

Another use for acid that has gained wide acceptance in a relatively short

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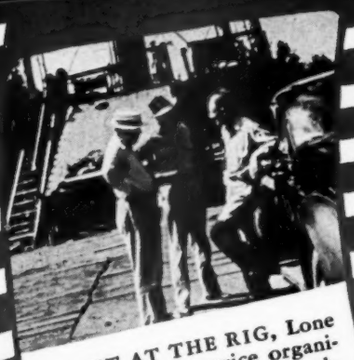

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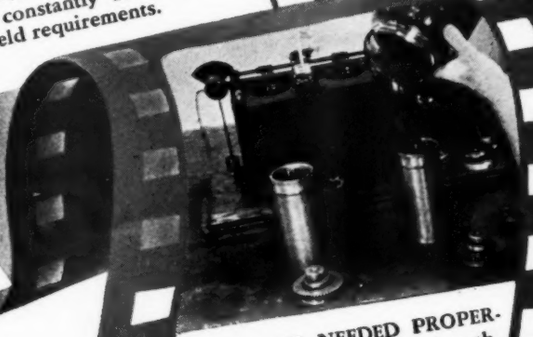

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period of time has been in the cleaning-up of sand formations and perforated liners or screens in wells where the gradual accumulation of carbonates has clogged the pore spaces and interfered with the flow of oil into the hole. Ordinary inhibited acid may be used inasmuch as the action desired is the attack of the cementing material rather than the silicates of the sand itself.[5]

Many of the improvements in treating technique have taken the form of incorporating within the water phase of the acid (usually 15 percent HCl), other reagents or additives that permit closer control of the acid.

The properties imparted to the acid by these addition agents include: (1) faster action of the acid when attacking dolomites; (2) slower action when the acid is used in readily soluble limestones; (3) reduction of surface tension of the acid, thus facilitating removal of the spent acid, and (4) the ability to "wet" or penetrate oil-soaked limestone more readily.

To maintain the pH of the spent acid and thus prevent the formation of a gelatinous precipitate of ferric hydroxide, obtained when acid-soluble iron compounds are present in the limestone, sulphur dioxide[6] or lactic acid[7] may be added to the acid.

To assist in dissolving cement, 30 percent aqueous acetic acid has been used;[8] to attack siliceous formations, hydrofluoric acid may be generated opposite the formation by combining hydrochloric acid and sodium fluoride[9] without the hazards attendant in handling the HF itself.

Selective Isolation of Specific Formations by Chemical Plugging

It is impossible to exaggerate the importance of controlling the ingress of salt water in oil-producing formations. Its magnitude is made apparent by the fact that, for every barrel of oil pumped from wells in the Mid-Continent and Gulf Coast fields, it is necessary to pump more than two barrels of salt water.[2]

Improved technique in setting and cementing casing has resulted in efficient water shut-off in newly completed wells; squeeze cementing and packers have succeeded in many instances in controlling the encroachment of water after a well is producing. No method yet devised is completely satisfactory under all conditions encountered, however, and it is for this reason that the development of chemical plugging materials has been watched with such keen interest.

One of the more successful chemical methods for selectively plugging formations, whether for the purpose of shutting-off water or for plugging-off gas sand to reduce gas-oil ratios involves the use of a three-component solution comprising ammonium bicarbonate, sodium silicate, and water.[10] Inasmuch as various percentages of the three components result in decidedly different setting times and hardness of the final product, an elaborate series of tests was conducted to investigate all possible compositions. The results of these experiments are shown graphically in Fig. 1. The cross-hatched area shows all mixtures of the three components that will form clear solutions and then solidify later. Some of the compositions outside this cross-hatched area form solids immediately and others form solutions that never solidify. Inside the cross-hatched area, many of the solutions—particularly those with low sodium-silicate content on the righthand side of the graph — have such short setting times that they have no value commercially. The compositions of practical value are all in the vicinity of the 30-min. and 300-min. setting-time lines.

Quick-Set Cement As Temporary Plug

Although cement is not customarily considered as a chemical it is indeed a mixture of chemicals and should be so considered.

Of considerable interest at the present time is the new gypsum cement, composed of 98 percent dehydrated calcium sulphate, that is proving so useful in various types of production work where a quick-setting, easily removed plugging material is needed.[11]

Surface Tension Reducing Agents

The reduction of the surface tension of acid to permit more effective drainage of the spent acid from the formation following an acidizing treatment has been a part of acidizing procedure for some time now and its value and purpose are generally recognized.

Of greater significance because of its wider scope of application is the current trend toward the use of surface tension modifiers that tend to "equate" the two extremely diverse liquids, oil and water, always associated to some extent in every oil-bearing formation.

These new chemicals are relatively newcomers to the petroleum industry, having been developed for specific purposes in other fields such as the textile and paper industries. Among those in which greatest interest is evinced at the present time are certain esters of sodium sulphosuccinic acid—the di-octyl, methyl-amyl, and di-amyl esters, and an alkyl sodium naphthalene sulphonate.[12]

Inasmuch as water is such an important factor in oil production, whether or not it actually is present in the oil itself, any means of altering the physical properties of the water so that its interference with oil flow will be minimized is welcomed by the production engineer.

One type of application in which the new chemicals are showing value is in the completion of new wells. As drilling is completed, the drilling mud in the hole is displaced by a solution of one of the synthetic wetting chemicals and sufficient time is allowed to permit the solution to permeate and wet the walls of the hole. When the well is then completed, it is usually found that the oil has a better opportunity to overcome the resistance to flow normally offered by the water and oil production may be more quickly established.

When old wells show a tendency to increase in water production and decrease in oil production, there is a possibility that certain strata in the oil sands are becoming saturated with water and will become established as water courses into the well bore. It has been found that treatment of the formation with one of the synthetic wetting agents under pressure or with an extended period of contact permits oil to encroach on these water courses, crowding out the water and permitting rates of oil production to be sustained.

Summary

From the many advancements in applying chemicals to production problems, it has been possible only to skim the surface, noting the developments that are attracting greatest attention at the present time.

It is generally agreed that the use of chemicals in the production of oil is only getting under way, and that the next few years should witness advances that will comprise an increasingly valuable contribution by chemistry to the already extensive technology of petroleum production.

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[12]*New Chemicals for Petroleum Production.* Bull. Amer. Cyanimid & Chem. Corp., New York, (1940).

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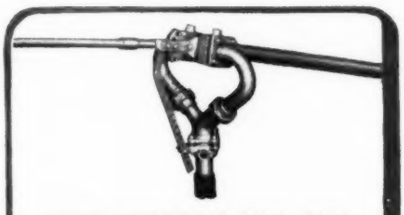

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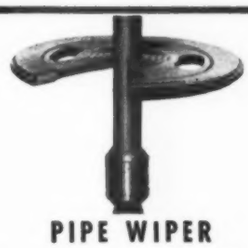

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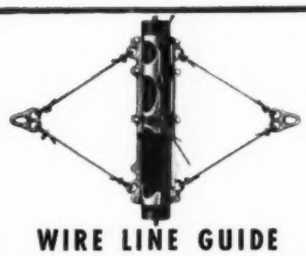

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By
H. LEE FLOOD
Associate Editor

PROBABLY no phase of production technique is receiving greater attention at the present time than the developments pertaining to multiple-zone completions. Although the general term "multiple zone" aptly describes the new methods, the many different arrangements and varied purposes for which the term is being used almost warrant a more extended nomenclature in order to distinguish between the various applications and better to emphasize their divergent objectives.

Because the possible combinations of multiple-zone principles are almost infinite in number and because, even in a relatively short time, present applications have become so varied, it is believed that greater good will be accomplished by stressing general principles in multiple-zone completions and citing only those specific installations that best illustrate present application. More important, it is hoped that by discussing certain applications that are only now in a nebulous form, thought will be provoked on the many purposes multi-zone completions may be made to serve.

Without splitting hairs concerning definitive terms, but rather to be all-inclusive, the terms multiple-zone completion or multiple-zone production should be permitted to cover all instances where more than one stratum in a single well is utilized for some purpose, whether it be for production of oil or gas that is delivered directly to the wellhead, for the production of gas from one formation and its use as a means of lifting oil from another formation, for the production of oil from one formation and the return of gas to another formation, or for any of the many other combinations that involve the use of two or more strata within a given well.

Thus given a rather liberal definition, multiple-zone production properly dates back to and includes the well completions in which oil from producing formations at different depths has been permitted to flow into and collect in a single casing, to be lifted to the surface, in effect as though there were only one producing formation. Although such practice is definitely of the multiple-zone type, the present widespread interest is in more recent (and usually more complicated) methods that have been developed during the last two or three years.

Although it is difficult to generalize, multiple-zone completions in which several formations are to be segregated usually require: (1) as many producing channels (tubing strings, annular spaces, etc.) leading to the wellhead as there are formations; (2) packers of the proper type and design to separate the formations; (3) beans or chokes to control the rate of flow from (or to) each formation; (4) check valves when necessary to prevent intercommunication between the formations, and (5) when one or more of the formations have been cased-off, either earlier before the potentiality of the zones was known or purposely as the well was completed, there must be a way of obtaining access to the formation, either through the casing or by removing it completely.

Usual Number of Zones

Two-zone and three-zone completions predominate in multiple production wells thus far. Except for added complications in the equipment required, there is no reason why four zones or even more could not be produced separately within a single well. Of course, the number is limited by the size of the hole inasmuch as each additional formation usually requires an additional string of casing or tubing.

In two-zone completions, the usual plan is to run one string of tubing through a packer set between the two formations and operate the lower zone through the tubing and the upper zone through the annulus between the casing and tubing. The word "operate" is used instead of "produce" inasmuch as in several installations gas is being returned to one formation and oil is being produced from the other.

One of the many variations in two-zone production permits production from an upper formation to be pumped in the conventional manner by sucker rods within the tubing and the lower production is flowed through the annulus.[1]

In the three-zone completions, two tubing strings are usually required, with two packers set between the three formations. Production from the lower zone enters the smaller tubing; production from the middle zone enters the annulus between the tubing strings, and the upper zone flows into the annulus between the casing and the largest tubing string.

Multiple-Zone Equipment

The increased interest in multiple-zone work and the insistent demands of operators who are daily evolving new applications for which they require special equipment not even available has encouraged nearly every manufacturer of production tools to design and perfect new equipment for multiple-zone completions.

Packers. Probably the greatest attention is being directed to the design of packers that will answer the special needs in multiple-zone wells. In view of the need for isolating the several formations, it is obvious that efficient packers are all-important in successful installations.

There are several packers now available that serve adequately in certain types of multi-zone installations. Other packers now being perfected by various manufacturers show promise of fulfilling the new requirements that have developed in multiple-zone installations. Among the desirable features that a packer should possess, the more important are the ability to "stay put" in the hole without either weight or tension being required and being capable of removal from the hole without having to be destroyed. Packing elements that provide efficient seals between the packer body and the casing

[1] "Applications of Drillable Material for Well Completions and Repair Work," by O. Hammer, A.P.I. *Drilling and Production Practice*, 1939, p. 503.

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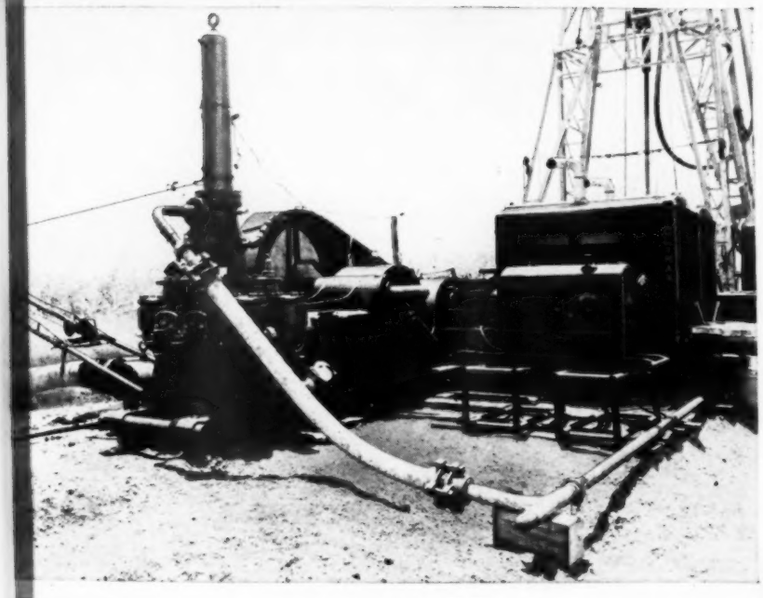

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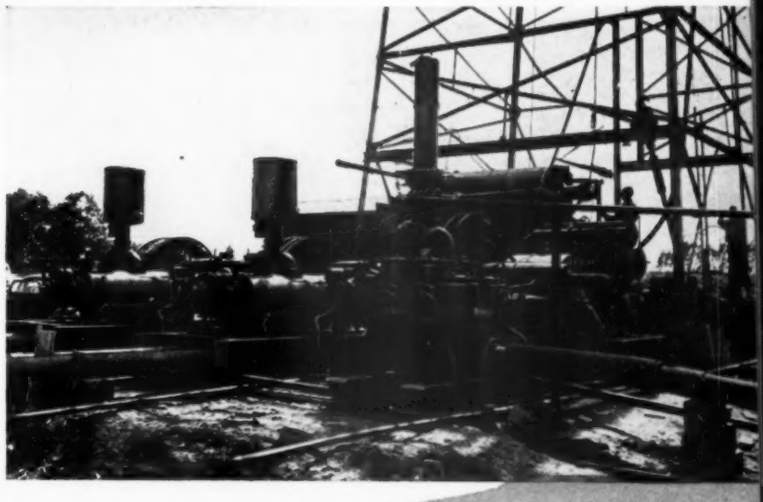

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and, when movement of the tubing through the packer is provided for, between the packer body and the tubing are, of course, prime essentials.

Side-door chokes. Removable bottom-hole chokes, known generally now as side-door chokes, are an outgrowth of the fixed bottom-hole choke developed originally as a means of controlling production rates, gas-oil ratios, etc.

With the increased demand during recent months for multiple-zone installations, the side-door choke has provided a convenient means for controlling the production from the various formations. When production from more than one zone is anticipated but multiple operation is to be deferred, a choke body may be installed in the tubing string with a blank nipple or mandrel in place. When desired, the blank may be removed and production admitted through a drilled mandrel.

Side-door chokes are being installed as standard equipment in New Mexico wells as a means of admitting gas from an upper sand to lift oil from the lower low-pressure oil sand when the well stops flowing. A packer is set between the two formations and the side-door choke is installed in the tubing string opposite the upper (gas) sand. When the well stops flowing, the blank mandrel is removed and replaced with a mandrel in which the proper size orifice has been drilled. Gas admitted to the tubing through this orifice supplies the energy to lift the oil from the lower sand and thus the flowing life of the well is extended.

The use of the side-door choke to control production from three zones in the Montebello field, California, is described in a recent issue.[2]

Drillable metal. Many of the multiple-zone completions made thus far have been so closely identified with the use of drillable metals that it is highly probable that development of this new technique would not have been so rapid had these alloys not been available.

The ease with which drillable metal may be removed from the hole has prompted its use in many types of subsurface equipment, such as packers, perforated screens, wash joints, tubing and liner hangers and many other tools of similar types.

Present Trend in Multiple-Zone Work

Currently, greatest interest is being shown in the use of multiple-zone completions in the deep producing wells of Texas and Louisiana, particularly in distillate fields where it is necessary to return gas to the formation as a necessary part of efficient exploitation of the distillate-type of reservoir. The considerable expense of drilling wells to depths of 8,000 to 11,000 ft. to serve only as input wells has prompted several operators to apply multiple-zone completion principles and thus develop a method of using a single well for the dual purpose of producing distillate and of returning the stripped gas to the formation.

This development work is proceeding intensively at the present time and it is too soon to describe in detail the arrangement of equipment. Several problems have been encountered that are unlike any previously dealt with in multiple-zone completions but these are rapidly being solved. The tremendous savings that may be derived by being able to make one of these deep wells serve the purpose of two, thus eliminating the cost of drilling the additional wells, are sufficient to justify all the development expense that may be required to perfect these multiple-zone completions.

Possible Future Applications of Multiple-Zone Completions

Stimulated by the many varied purposes for which multiple-zone completions have been used to date, a little thought concerning the potential applications of these principles will reveal a wealth of possible uses. Particularly when the scope of "multiple zone" as a term is broadened to include all types of formations, whether they be oil, gas, or even water.

Although at present the greater amount of attention is being given to multiple-zone arrangements that provide several independent channels connecting the underground formations with the wellhead, it is of even more importance to look into the future and consider the tremendous possibilities that will be opened up with continued perfection of methods by which communication between formations may be established and controlled without ever coming to the surface and back again.

A forerunner of this type of arrangement is in the present installations where gas from one formation is used to lift oil from another. Extensions of this type of completion, using devices now available and others now in the development stage, might easily permit the use of gas from one formation to repressure or maintain pressure in another formation until such time as gas compression at the surface was necessary.

It has been suggested that in many instances where high-pressure water sands are known to exist below the oil-producing formations, rather than carefully avoid drilling into these water sands as at present, they might be tapped and the well completed in such a manner as to employ the water at high pressure to create a water drive in the oil-bearing formation.

A recent ruling[3] by the Attorney General of the State of Texas has significance to all who are interested in the use of gas from one formation to lift oil from another formation within the same well through a single tubing. The opinion, requested by the Railroad Commission, specifically concerned "the right of an operator to utilize gas produced from an upper horizon in lifting the oil produced from an oil sand at a lower horizon, without first producing the gas at the surface."

In the letter to the Attorney General, the Commission described the situation as follows:

"An operator in a certain field in this State [Texas] has a well which will produce gas from one horizon and oil from a deeper horizon. This operator has equipped his well with casing and tubing, and will perforate the casing at the level of the gas sand and also at the level of the oil sand. A packer has been installed in the annular space between the tubing and casing so as to seal off the lower oil horizon from the upper gas horizon. The gas * * * * will not be produced at the surface through the annular space, but will be admitted to the tubing through a _____ flow valve. In the tubing the gas will be utilized in lifting the oil and water from the lower oil horizon. The valve is so constructed that no fluid or gas from the tubing can escape back into the annular space, or into the oil horizon."

In answering the Commission's question concerning its authority to grant permission for this practice when it "has found that such an operation is an efficient form of gas lift," the Attorney General, after reviewing the law pertaining to this and related subjects, was of the opinion that the statutes do not "absolutely require that gas, to be used as gas lift, must first be produced at the surface through a separate string of casing, and then reinjected into the well."

This ruling should have a far-reaching effect on future progress of multiple-zone completions within the State of Texas and may even serve as a guide to regulatory bodies elsewhere in recognizing the modern developments whereby single wells may now be equipped to operate efficiently even when several zones are involved.

[2] "Multiple Production from Several Zones Controlled by Bottom-Hole Chokes," by Wallace A. Sawdon, *The Petroleum Engineer*, June, 1940.

[3] Opinion No. 0-2245, approved May 20, 1940.

Pressure Data Obtained With Formation Tester Now Form Basis for Accurate Well Analysis

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Complete records of pressure data aid in predicting well performance, plotting pressure contours, and serve as guide in shutting-off water

By WALLACE A. SAWDON
Pacific Coast and Foreign Editor

THE practice of testing a productive zone with a formation tester before setting casing has become so widely adopted that the standard methods followed and the equipment being employed are known to operators throughout the world. Whenever practicable, standard procedures should be followed, but the experience gained in various countries in meeting specific problems has developed methods peculiar to certain subsurface conditions that may be encountered in other localities. Of considerable importance also is the utilization of formation pressures that are recorded when making the tests. Water shut-off tests after cementing are now being made extensively in the United States and the practice developed in making these tests could probably be adopted more extensively to excellent advantage in other countries.

Some of the newly developed methods for using the formation tester involve primarily the keeping for future use of formation pressure records and fluid data. One practice that is followed in certain areas of the East Indies, is illustrated in Fig. 1. The same method is applicable to fields elsewhere when a series of oil-producing and water-bearing zones is encountered requiring that each zone be cased and cemented-off for later simultaneous multi-zone production from the several oil strata after pressures successively equalize.

The well depicted in Fig. 1 is not any specific well but is representative merely of the general testing method being used. After the surface string is landed and cemented at approximately 1500 ft., drilling is continued in new areas and in edge wells until the first likely horizon is picked-up. In a 6000-ft. well this may be slightly below the 4000-ft. depth. The formation tester is then run every 100 ft. as the well is deepened and pressure records are taken in both oil- and water-bearing formations. After drilling through or into the lowest productive horizon the casing is cemented solid from the shoe to a point above the highest water or oil sand penetrated below the water string.

The lowest sand, which normally has the highest formation pressure, is then gun-perforated and produced. In the case illustrated, this sand had a pressure of 2600 lb. per sq. in. and was produced alone until its pressure declined to 1800 lb. per sq. in., which was the formation pressure recorded for the next sand above. This upper sand was then gun-perforated and the two zones produced together until their pressure declined to 1400 lb. per sq. in., the recorded pressure of the top sand. The latter sand was then perforated and all three formations were produced together.

Incomplete cement encasement sometimes occurs when the cement slurry is placed around the shoe for the entire distance behind the pipe and frequently necessitates squeeze jobs through perforations to shut-off the water sands and protect the producing zones when it comes time to produce them. As water sands occasionally are found to have higher formation pressures than the oil sands, steps should be taken to protect the oil zones by cementing to obtain a water shutoff immediately upon completion of the well. Based on the pressure and fluid data taken when formations are drilled, however, the potentialities of the productive zones are known and reduced production or the presence of water will not be misleading.

Pressure records obtained with a formation tester while drilling are, in many cases, not utilized to their fullest extent. In the first place, such records give the true initial pressure in a formation if the pressure-recording equipment in the tester is accurate and properly arranged to eliminate all other influences.

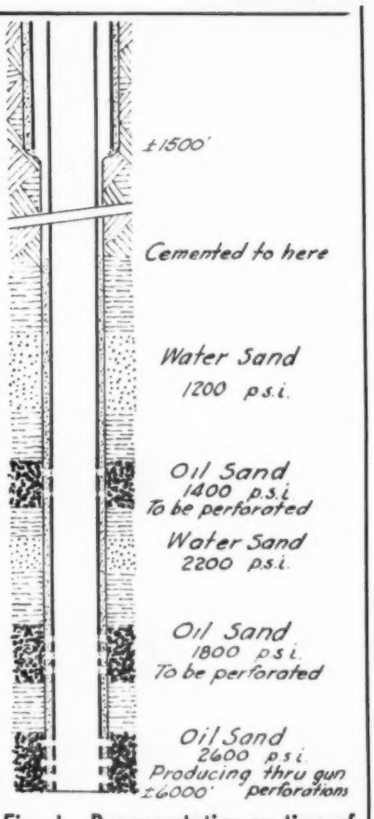


Fig. 1. Representative section of well in the East Indies, showing pressures determined by formation tester

Bottom-hole pressure surveys are taken periodically in many fields to guide production practice. By combining pressure records with core analysis of the sand an informative preview of production performance can be obtained before the well is completed. When flow occurs during the test the productivity index can be computed with considerable accuracy by measuring the rate of production and using the appropriate pressure figures. If there is no flow during the test an approximate figure can be obtained by computing the volume of fluid in the sample, taking into consideration the length of time required for its entry and using the average flowing pressure during this period. By using the productivity index the rate of production can also be estimated and to a more accurate degree than will be indicated by a flow test through the tester.

In multiple-zone wells similar to the one illustrated in Fig. 1 but in which the casing or liner through the producing series is not cemented, the low-pressure zones will become thief sands when the well is shut-in. The knowledge of initial pressure conditions in various strata is essential for economic completion of a well, no matter what specific method is used.

Considering a producing field in its

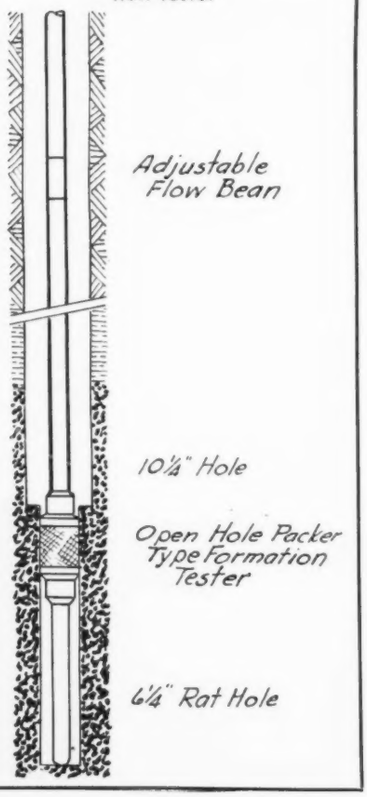
entirety, the pressure records obtained when making formation tests in individual wells will be valuable in the compilation of data for pressure contour and productivity index maps. The more data obtained from different wells, the better will be the results and the more useful will the pressures be in guiding general production policies.

When sloughing formation makes it difficult to obtain a satisfactory seat for the packer and when it is undesirable to put in a cement plug, a method followed in the Gulf Coast area can often be used to advantage in making a formation test. This is particularly adaptable to certain areas in Venezuela and Burma but can be employed in most cases when the formations will not stand up.

As illustrated in Fig. 2, an open-hole packer is run and set just below the top of the rathole. A combination rathole packer with open-hole packer above can be used but the smaller, open-hole packer in the rathole has the advantage of being the same diameter in its unexpanded condition as the rathole itself and all expansion is utilized against the wall. The total force exerted by the expansion of the rubber is thus applied against the wall of the rathole as the weight of the drill pipe is carried by the anchor.

The pressure should be bled-off gradually and to accomplish this the trip valve is made up four or five stands above the retaining valve and an adjustable flow bean placed between these valves. The pipe between the valves is filled with water in order to create a back-pressure that the formation pressure will have to oppose to enable flow to take place through the testing tool. The adjustable flow bean provides for a small flow of fluid upward into the drill pipe with a gradual increase of flow as the pressure below the packer diminishes.

Fig. 2. One method of setting open-hole packer type formation tester



In plugging-back in open hole to a sand where a formation test is desirable, either of the two general methods illustrated in Fig. 3 may be employed. With the one using the rathole packer, the hole above the sand is wall-scraped for approximately 60 ft. and a cement bridge put in this enlarged hole. The bridge is then drilled through and the rathole packer set on the cement shoulder. A cement plug previously placed below the sand isolates the zone to be tested.

The method employing the open-hole packer has a 60-ft. cement bridge built in an enlarged hole below the sand. The equipment is set on this bridge, which, with the packer packing-off the hole above the sand, isolates the zone for the test. In both methods the standard testing procedure is used after the packer is set.

Water Shut-Off Tests

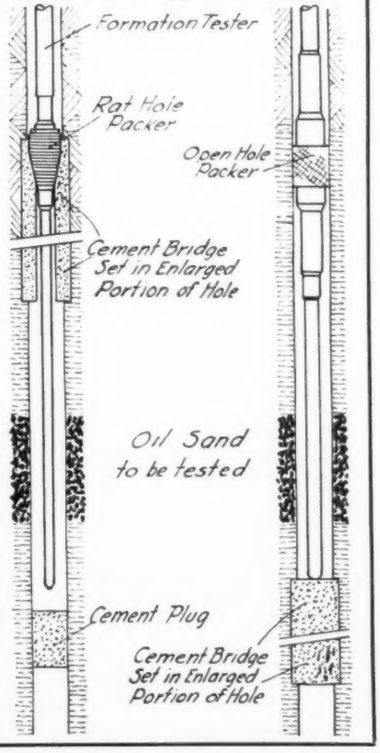
The formation tester is widely used in various parts of the United States to make the important water shut-off test after cementing a string of casing. In California this method of testing is authorized by the State Division of Oil and Gas as it eliminates danger from casing collapse and is believed to give a more conclusive test. A casing packer is used, of course, for the purpose and the pressure recorder is attached to the anchor extending below the packer. The pressure recorder operates as an individual unit and is separated from the equipment above by a blank disk in order to measure the actual pressure of any fluid entering the hole below the packer.

Under California regulations, which have been found very effective, the cement is drilled-out to a minimum of 5 ft. below the shoe and precautions then taken to make sure no cement is left in the pipe to interfere with the operation of the tool. With the hole full of fluid the tester is run in on empty drill pipe and the packer set in the casing, usually in the bottom joint just above the shoe.

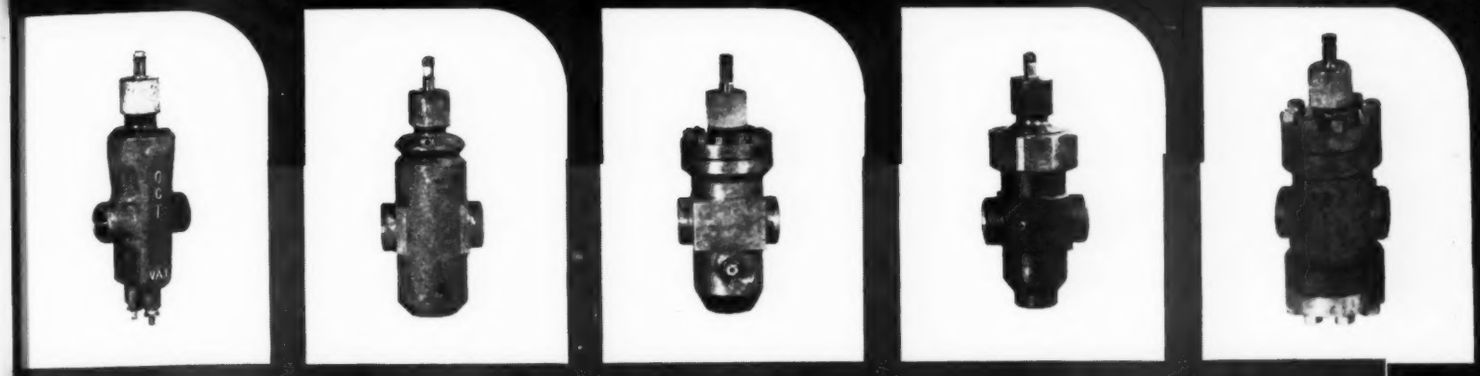
After the test has been made the fluid rise is checked with the pressure record to assure there is no erroneous interpretation based on the height of fluid. When any fluid is brought up in the tester a salinity test is also performed. Water sometimes enters from leaky drill pipe or other sources above the point of test but within the casing, and by knowing the character of this water after comparing the fluid rise with the pressure record, a more certain determination of the success of the shut-off can be made.

The formation tester is also used for testing water shut-offs when the cement job has been done above the shoe as is the case when cementing combination strings or blank casing or liner sections between producing zones. To do this the cement in the casing is drilled-out and holes perforated at approximately the point where the cement was discharged through ports in a cementing collar or through perforations provided for that purpose at the bottom of a blank section of pipe. This procedure is necessary because any discharge holes used for the passage of slurry in performing the cement job will be plugged by set cement and it is essential that access into the casing around the cement job be provided for any fluid that has not been effectively shut-off by the cement. The test is conducted with a casing packer type of formation tester in the same manner as at the shoe and with salinity tests made if any fluid is brought up in the tester.

Fig. 3. Two methods of plugging-back to test upper formations


Formation Tester
Rat Hole Packer
Open Hole Packer
Cement Bridge Set in Enlarged Portion of Hole
Oil Sand to be tested
Cement Plug
Cement Bridge Set in Enlarged Portion of Hole

O·C·T CYLINDER GATE VALVE



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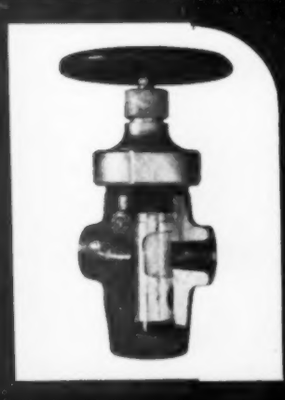

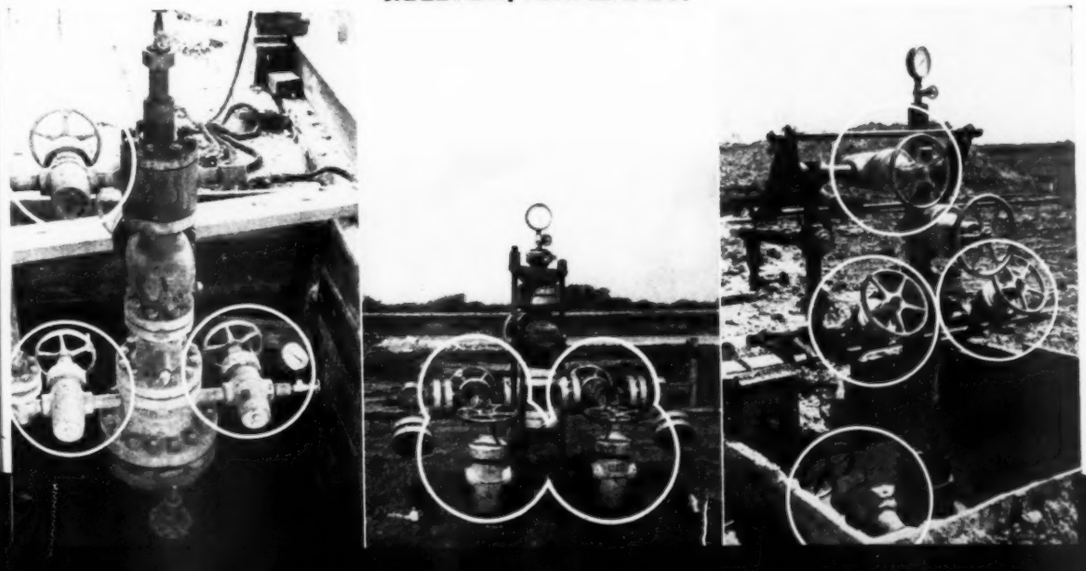

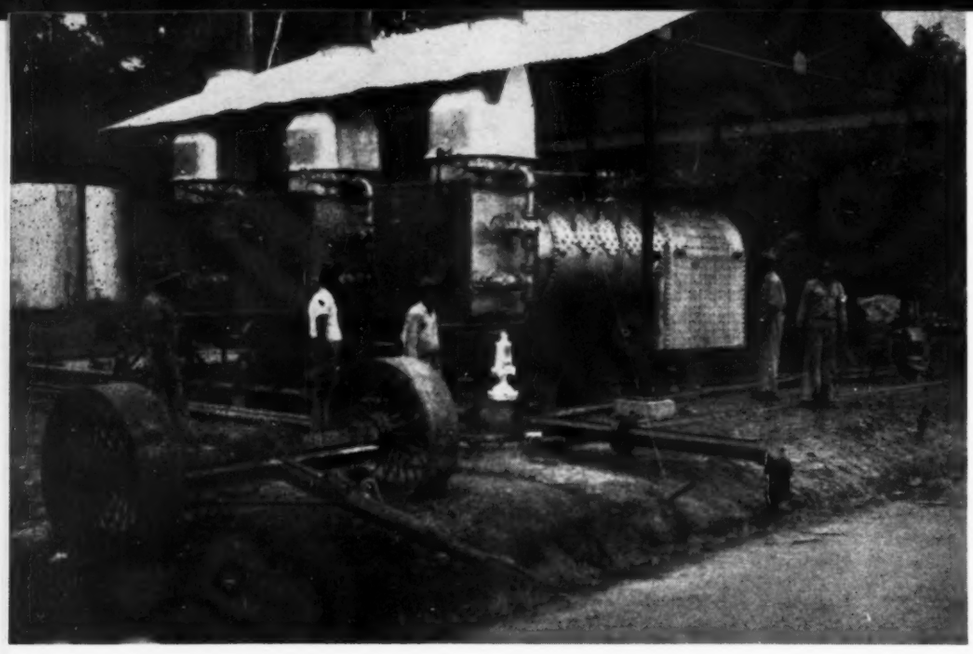

P 425.
P 115.1

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A PETROLEUM ENGINEER EXCLUSIVE FEATURE

A Driller in Trinidad Gives First-Hand Information on Methods

Central mud plants deliver mud of any type at any time of day or night — gasoline-driven and Diesel rigs employed—manner of completing wells

By R. G. BENNETT, Senior Driller,
Trinidad Leaseholds, Ltd., Trinidad, B.W.I.

THE subsurface conditions in Trinidad being ideal for rotary drilling, rotary rigs exclusively are found throughout the oilfields of the southern portion of the island where most of the oil is at present being produced. These range from the heavy-duty, four-speed, locally-unitized, old headboard type, Diesel rigs to small 1500-ft. gasoline-driven rigs.

The average depth of most wells is somewhere between 3000 and 4000 ft., although some very good shallow holes have been drilled and excellent production obtained at depths of 1000 to 1500 ft. The deepest well drilled was somewhere past the 10,000-ft. mark.

The time taken to drill these wells is rather extended because of the considerable dip of the strata and frequent changes of formation, making it very difficult to maintain a straight hole. In spite of this, most of the wells drilled during the last four years are as nearly vertical as possible, a 3000-ft. well being generally no more than 2½ to 3 deg. off at bottom.

Three- and four-way bits are used principally but it is often necessary to change to rock bits to drill through sandstones or thin beds of very hard sand. After drilling these formations it is necessary to pull out and return to the three-way bit when sticky shale is encountered. This necessitates frequent round trips for bit changing and tends, of course, to slow up the drilling.

Mud Control

The geology of Trinidad is considered to be about the most difficult in the world, and previous to 1930 a considerable number of blowouts occurred because of the relatively small number of wells that had been drilled from which knowledge of the underlying strata could be obtained. Several hundred wells, however, have been drilled and electrically logged since then, and the knowledge so obtained has given the geologists data from which to locate high-pressure horizons and enabled the mud engineer to plan his mud program intelligently.

R. G. BENNETT

was born in Bognor Regis, Sussex, England, in 1900 — Educated at St. George's College, Weybridge, Surrey —Joined army at age of 16 and during year's flying in France in first World War shot down seven enemy planes before being shot down himself and rather badly wounded — After the war he went to Trinidad for Trinidad Central Oilfields — In 1924 joined Shell in Venezuela as a driller — Returned to England during depression years and drilled water wells—In 1936 again went to Trinidad, this time with Trinidad Leaseholds, Ltd., and is still with that company—For several years has been a senior driller.

Before a well is spudded-in, a program of the casing, depth to be drilled, etc., is posted on the rig and included in this is a schedule of the weight and

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type of mud to be used, depending on the type of formation to be drilled. If there are no high-pressure gas sands above 2500 ft., shale mud is used to that depth, after which the mud is changed and barytes mud used, usually at a weight of 110 lb. per cu. ft. Should this mud become gas-cut during the course of drilling or show signs of heaving, the weight is increased to 120 lb. per cu. ft. upon the decision of the mud engineer.

In the larger fields a central mud plant is established, from which any type or weight of mud may be obtained at any time of day or night. Mud not wanted at the well is pumped back to the mud plant and is reconditioned.

The mud engineer is entirely responsible for the type and weight of mud to be used on the various drilling wells. He visits each well every day, takes a sample of the mud, has it analyzed in the laboratory, and makes his decisions according to the results obtained. He also gives written instructions every day to the driller on tour as to the weight and viscosity at which the mud is to be kept, with instructions as to the treatment to be given should the weight or viscosity increase. Should the weight decrease, the driller adds barytes and a thinning agent to bring it back to the given weight. For decreasing the viscosity, tannic acid or other chemicals may be used depending on the instructions of the mud engineer. This method of mud control is extremely good, and relieves the toolpusher of a grave responsibility. It also gives the driller added confidence in the knowledge that if he gives his full coöperation to the mud engineer, nothing of a very serious nature can occur.

Casing

On the deeper wells a 13⅜-in. conductor string is usually run and cemented at about 1500 ft.; then a 9⅝-in. string is run and cemented at a depth of 5000 to 6000 ft. The well is finished with a 6⅝-in. blank string of length depending on the depth of the well and consisting of 20- and 28-lb. casing, the latter being placed opposite the sands to be shot and produced.

In the shallower wells a 9⅝-in. conductor string is usually run to approximately 600 ft., and the well finished with a blank 6⅝-in. string.

Before the advent of gun-perforating some very complicated combination-string cement jobs were done, owing to the numerous oil and water sands passed through.

Well Completion

After the 6⅝-in. blank string has been cemented and allowed to set, 2-in. upset tubing is then run to bottom, and the mud conditioned or changed as the case may be, to a sufficient weight and viscosity to enable it to withstand any expected pressure after shooting.

The tubing is then withdrawn and a heavy 6⅝-in. master valve installed on the casinghead. The shooting program is then carried out and the tubing run back to bottom, where a good two hours' circulation is necessary to circulate-out any foreign matter from the hole. Sometimes the gas-cut mud does not permit this, in which case the tubing is promptly pulled upward 25 or 30 ft. from bottom and landed, the Christmas tree and fittings hooked-up, and the well washed-in through the tubing and out the casing. As soon as the well shows signs of kicking, the pumps are stopped, the casing closed, and the well is allowed to come-in through the tubing. The size of flow bean used depends on the type of well and the decision of the production engineer.

Foreign operations require complete shop facilities for maintenance and repair of equipment

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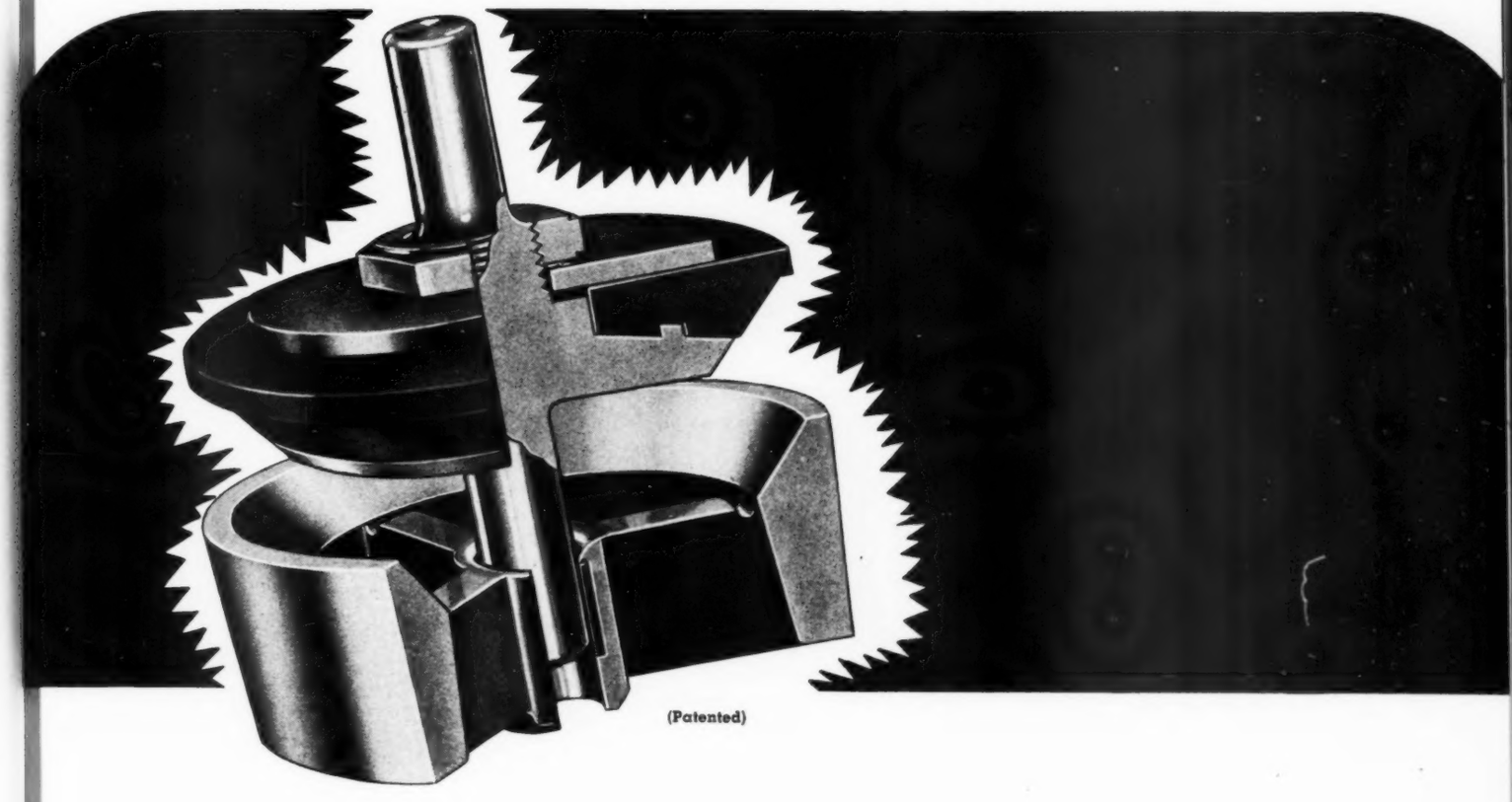

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P 729.6
P 222.2

Preparation of Isopentane and Isooctane From Ethylene*

Polymerization of ethylene in steps followed by hydrostabilization suggested as method for the manufacture of high octane fuel

By A. S. VELIKOVSKII, F. I. PODOL'SKAYA, and S. I. POLONSKAYA

Central Institute of Aviation Fuels and Oils, Moscow, Russia

ABSTRACT

THIS IS A preliminary report on the polymerization of ethylene to C_5 and higher hydrocarbons in two steps. Using a gas containing 95-97 percent ethylene in the presence of a catalyst SK (not further identified), the polymerization experiments were carried out at 250 and 300°C., at atmospheric pressure, and during a 10-sec. contact period. At 300° the reacted ethylene amounted to 89.7 percent per pass and the products contained 32.3 percent 2-butene and 49.5 percent liquid hydrocarbons on the reacted ethylene. The liquid products containing appreciable amounts of 2-methyl-3-butene (below 30 percent in tests at 300°) and octenes were hydrogenated. It is thought that yields of *iso*pentane greater than 50 percent on the initial ethylene are possible; butane can be polymerized separately and hydrogenated to produce *iso*octane. After removal of the pentene fraction the liquid product containing as much as 30 percent hexenes is still a good blending fuel. The same direction of the polymerization reaction is observed with a content of 20 percent ethylene in the feed gas.

Introduction

Unsaturated gases from pyrolysis and cracking are treated at present as raw material for different syntheses and principally for preparation of high-octane components of aviation fuel. From the standpoint of present-day technology, however, the gaseous unsaturated hydrocarbons do not all have the same value as starting material for preparation of high octane fuels. Butenes are converted by polymerization into *iso*octanes; propene can be converted into isopropyl ether.

Ethylene was not, until now, converted into high-octane fuel, at least not when used alone. By usual polymerization, for instance, with phosphoric acid as a catalyst, and after hydrostabilization, a fuel is obtained that has a relatively low octane number of the order of 75 and low susceptibility to tetraethyl lead (TEL). Use of ethylene for production of high-octane fuels is considered in processes where ethylene is one of the components treated, such as alkylation of benzene or butene. The potential volumes of ethylene available are not large; in gases produced by liquid-phase cracking it amounts to only 2 percent by weight. It is true that in the pyrolysis of gases its content may be considerable (21 percent by weight). An intermediate position in this respect is occupied by gases of reforming operations.

Although catalytic polymerization of ethylene, until now, has not produced satisfactory high-quality aviation fuel, it seems to the writers that such fuel could be obtained by changing the course of polymerization, namely, by using polymerization in steps. This method is outlined in the present article.

The experiments reported were performed with a gas containing 95-97 percent ethylene, obtained in the laboratory by dehydration of ethyl alcohol over aluminum oxide. Even a 20 percent content of ethylene in the starting gas, however, does not change the direction of the reaction.

Experimental Part

Orientation experiments designed to determine the effect of temperature on polymerization of ethylene in the presence of the catalyst SK were carried out at 250 to 300°C. under atmospheric pressure using a 10-sec. contact period. Many runs were made until sufficient liquid hydrocarbons were collected for fractionation. The yields per pass are reported in Table 1. Fractionation under efficient rectification gave the results shown in Table 2.

As freshly polymerized gasoline usually contains a large amount of gaseous hydrocarbons, the condenser and receiver were cooled with ice. A tube from the receiver led to another receiver cooled to minus 50°C. with dry ice and alcohol. Some product was collected in both cases in the second receiver. This product was evaporated into gasometers and analyzed as shown in Table 3. Considering the weight of this product, the distillation losses amounted to 3-10 percent.

The distillation was carried out in both cases as follows: the temperature of the vapor was kept at 20°C. for a

TABLE 1

Temperature of the experiment, °C.	Percent reacted	Yield			
		2-butene		liquid hydrocarbons	
		on the ethylene passed, percent	on the reacted ethylene, percent	on the ethylene passed, percent	on the reacted ethylene, percent
250	37.9	26.7	70.3	5.0	18.0
300	89.7	29.0	32.3	44.5	49.5

TABLE 2

Boiling range of the fraction, °C.	Percent by weight of the fractions obtained in distillation of liquid polymers prepared at:	
	250°C. (charge, 171.2 g.)	300°C. (charge, 173.4 g.)
From I.B.P. (20°) to 40°	23.9	29.3
40–73	30.5	23.2
73–98.5	2.4	3.8
98.5–110	6.0	6.2
Residue	18.9	19.8
Total	81.7	82.3

*Neftyanoe Khozyaistov (The Petroleum Industry), Vol. 20, No. 9, pp. 41-43, September, 1939. This translation is submitted by the Petroleum Division of the American Chemical Society. The Petroleum Division, however, assumes no responsibility for the facts and opinions presented in this paper, nor does it necessarily endorse statements made therein.

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An early error in calculation is multiplied many times

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prolonged period of time, after which it was rapidly (within not more than one minute) increased to 67°C. and kept at this temperature for a long time; then the temperature was again increased but more slowly.

The specific gravities and refractive indexes of the fractions obtained are given in Table 4. It follows from the distillation results that the polymerization produced appreciable amounts of *iso*pentene, the boiling point and specific gravity of which agree completely with 2-methyl-3-butene (boiling point 20.2°C. at 771 mm. mercury, d^0 0.648). The properties of other pentenes, normal and iso, differ sharply from those observed.

Formation of pentene from ethylene in polymerization was first observed by Storch and by Burk and coworkers. These writers think that formation of pentene is connected with formation of propene as follows: $C_4H_8 + C_2H_4 \longrightarrow 2C_3H_6$. Consequently formation of propene is a secondary reaction and is accelerated with increases of pressure, of temperature, and of contact period. The yield of pentene obtained by these writers is small. In the present experiments the yield of *iso*pentene was much higher at 300° than at 250° and amounted to almost 30 percent of the liquid product of polymerization, in contrast to the very low yields of this hydrocarbon obtained by the first of the above-mentioned writers in polymerization of ethylene.

The boiling point of hexenes (in the secondary distillation the product distilled uniformly at 63-69°) shows that these do not possess two side methyl groups as in that case they would boil at 41-57°. As 2-butene is formed in the polymerization of ethylene, formation of especially large amounts of 3-methyl-2-pentene should be expected in this case—which apparently actually took place judging from the constants observed.

TABLE 3

Temperature of the experiment, °C.	liters	percent				°C.	Pressure, mm. mercury
		C_3H_6	C_3H_8 and C_4H_8	CO_2	O_2		
250	6.8	1.4	90.6	0.2	2.0	16.0	765.3
300	4.0	1.4	92.4	0.2	1.4	16.3	751.0

TABLE 4

Boiling range of the fraction, °C.		Properties of the liquid polymer fractions obtained at:			
		250°C.		300°C.	
		specific gravity	refractive index	specific gravity	refractive index
To 40°	C_5	d(4/4) 0.6472	n(4/D) 1.3818	d(4/4) 0.6466	n(4/D) 1.3810
40-73°	C_6	d(20/4) 0.6915	n(20/D) 1.3980	d(20/4) 0.6895	n(20/D) 1.3978
73-98.5°	C_7	d(20/4) 0.7184	n(20/D) 1.4111	d(20/4) 0.7104	n(20/D) 1.4090
98.5-110°	C_8	d(20/4) 0.7321	n(20/D) 1.4130	d(20/4) 0.7348*	n(20/D) 1.4196*

*Boiling range of this fraction 98.5-118°.

Heptenes require propene for their formation. For this reason their absolute amount and that calculated on the liquid product are higher in polymerization at high temperatures. Their yield even at 300° was very low (3.8 percent on the liquid portion).

The fractions whose boiling points correspond to those of hydrocarbons possessing 8 or more carbon atoms contain marked amounts of naphthenes and aromatics as seen from the analysis of the mixture of hydrostabilized products of polymerization obtained in a number of experiments and shown in Table 5.

In the usual polymerization of ethylene, gasoline with an octane number exceeding 80 cannot be obtained, and the octane number is greatly lowered by hydrostabilization. It seems to be more advantageous to produce butene and *iso*pentene by polymerization, then polymerize butene separately, producing after hydrogenation considerable amounts of *iso*octane of octane number 85 and very susceptible to TEL. *Iso*pentene is converted by hydrostabilization into *iso*pentane of octane number 91 to 100 when treated with TEL. The yield of these products from non-extensive polymerization with recirculation can exceed 50 percent on the initial ethylene. The mixture of *iso*pentane and *iso*octane is a highly valuable component of 100-octane gasoline.

The liquid hydrocarbons after removal of the pentene fraction still represent a fuel of good blending octane number suitable, for instance, for addition to straight-run gasoline of octane number of the order of 50 for preparation of aviation fuel.

Conclusion

By polymerization of ethylene in steps followed by hydrostabilization considerable amounts of *iso*pentane and *iso*octane can be prepared.

Acknowledgment

Laboratory assistants A. V. Guseva and G. A. Bronshteĭn participated in the experimental part of the work.

TABLE 5

No.	Boiling range of the fraction, °C.	Yield, percent	d(20/4)		Drop in specific gravity	Aniline point		Drop in aniline point	n(15/D)		Depression of refractive index	Iodine number	Specific refraction	Hydrocarbon composition, percent			
			before sulfonation	after sulfonation		before sulfonation	after sulfonation		before sulfonation	after sulfonation				unsaturated	aromatics	naphthenes	paraffins
1	Starting gasoline		0.7177	0.7023	0.0154	57.0	68.7	11.7	1.4268			0.970			17.5		
2	I.B.P. to 32	10.29	0.6236						1.3595								100.0
3	32-43	1.91	0.6256						1.3620			0.129		0.037			100.0
4	43-59	5.59	0.6497						1.3718	1.3720		0.067	0.3498	0.022			100.0
5	59-65	17.64	0.6622	0.6630					1.3770	1.3770	0	0.113	0.3469	0.038			100.0
6	65-77	4.41	0.6703	0.6694	0.0011				1.3816	1.3813	0.0003	0.195	0.3471	0.066			100.0
7	77-89.5	2.35	0.6853	0.6844	0.0009				1.3880	1.3880	0	0.146	0.3448	0.057			100.0
8	89.5-98.5	3.82	0.6973	0.6957	0.0016	68.7			1.3945	1.3932	0.0013	0.170	0.3440	0.067	1.5		98.5
9	98.5-115	10.88	0.7138	0.7087	0.0051	66.5	69.6	3.1	1.4031	1.4002	0.0029	0.158	0.3422	0.071	3.4	5.0	91.5
10	115-125	5.60	0.7246	0.7188	0.0058	65.1	69.2	4.1	1.4090	1.4048	0.0042	0.345	0.3408	0.155	5.9	16.0	78.0
11	125-175	14.85	0.7765	0.7481	0.0284	49.4	69.2	19.8	1.4380	1.4175	0.0205	1.337	0.3365	0.650	29.7	26.1	43.5
	Residue	20.14															
	Losses	2.52															

Note. The distilled product of hydrogenation was somewhat aired.

P 444.

Mixing slurry to cement 10¾-in. casing in well at Bahia, Brazil

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
WALLACE A. SAWDON
Pacific Coast and Foreign Editor

Cementing Casing Under Adverse Conditions is Routine Practice in Foreign Fields

In remote areas where supplies and tools are limited in variety, ingenuity and skill must fill the gap in obtaining successful cement jobs

THE cementing of a string of casing is an important factor in the subsurface construction of an oil well; yet in many remote foreign fields this important operation must be performed under most difficult obstacles when often the type of cement available is not even suitable for the specific job.

Manufacturers of cement in the United States coöperate closely with oil-field operators and are meeting to a great extent the requirements for cement performance. A very close approximation of the qualities desired is therefore available in most oil-producing areas of this country; but in the many remote fields throughout the world that are situated far from the source of supply, where stocks must be ordered far in advance of their use, the selection of the best kind of cement for the job is seldom possible. It is probable, however, that cement better suited to particular conditions common to a definite area could be stocked, as American manufacturers of cement have done so much research work in regard to oil-well cements that they are able to supply operators with better grades of cement than are now being used in many countries.

The selection of cement is governed principally by time and temperature; and when the temperature is abnormally high, it has much to do with the time that must be allowed for placement of the cement around the pipe. The time required for placement is otherwise governed by the depth of the hole, amount of cement, size of casing, pump capacity, any resistance to the free passage of the slurry, and other factors that may be peculiar to the particular operation.

Pumpability of the cement until it is in place is of primary importance in the selection of the cement. For short strings, a cement with comparatively rapid set is usually satisfactory and ordinary Portland cement is frequently employed. High early strength cements are generally used for surface strings but the cement should be sulphate resistant when sulphur is likely to be encountered either in the surface string or other short strings.

The "slow set" or "high temperature" cements, when available, are being used extensively for deep wells or for any job where temperature may accelerate the setting to an extent that there may be danger of the slurry becoming unpumpable before the entire batch of cement has been placed. When the thickening rate of the cement is so rapid that it cannot be pumped readily at all times before the job is completed there is not only a possibility of damage to the equipment but also to the cement itself as continued agitation or movement of the slurry after its mobility begins to decrease rapidly will cause granulation of the cement when it sets. This action causes an increase in permeability of the set cement and results in a weaker cement with impaired bonding power.

The importance of knowing the time required for displacement of the

Starting-in a 10¾-in. string of casing equipped with float shoe in a well being drilled in Brazil by Consellio Nacional de Petroleo

cement is obvious. The total time allowed for the job, however, must not only include mixing and displacement time but also an allowance for contingencies. This extra time allowance should give due consideration to the reliability of the surface equipment because inadequate pumping facilities or poor equipment that might cause a shut-down during the job might result in a failure. With the approximate cementing time estimated and the maximum temperature assumed for the slurry, a thickening time test can be made to determine the proper type of cement to use. Even when using cements having specified setting times the thickening time test is advisable as the character of cement may vary and cement kept for a long time may alter in quality to some extent.

In many countries far from the source of supply there will frequently be only one kind of cement available, and that cement will have to be used. Accelerators or retarding agents can sometimes be used to advantage, particularly retarders when high temperatures are present in deep wells, as is usually the case.

Increasing the water-cement ratio by the addition of water will lengthen the thickening time appreciably and it is frequently possible to use a ratio that will give the necessary thickening rate without decreasing the ultimate strength of the cement to such an extent that the job will be unsuccessful. High water-cement ratios, however, will not produce a cement as strong as slurry made with less water. The weakening effect on both compressive and tensile strength of the cement by the use of high percentages of water has long been recognized. Higher water-cement ratios also increase the volume of slurry but decrease its weight.

It is seldom convenient or easy to make extensive field tests on cement and as the most important characteristic is the limit of pumpability, the thickening test is probably of greatest value. The cement must, of course, be in good condition and in countries where large stocks have to be carried, assurance must be made that the cement has not deteriorated.

The effect of pressure on cement is favorable under almost every condition and is of particular advantage when high water-cement ratios have to be used. The increased strength given to cement by pressure is shown by Fig. 1. This increase results from the pressure forcing water out of the slurry and making a denser cement with lower permeability.

No matter what the water-cement ratio may be, evenness of the mix and speed in both mixing and displacing the

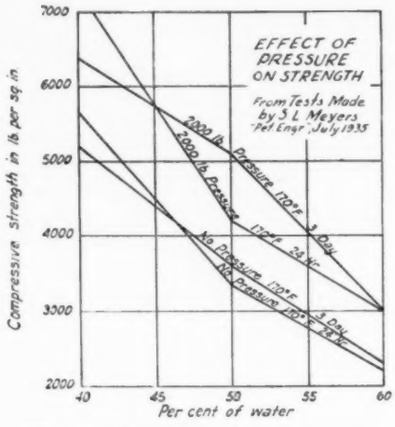


Fig. 1. The effect of pressure on cement is to increase its strength

slurry will have an influence on the success of the job. The surface equipment used and the ability of the cementing crew are thus important factors to be considered.

When using a prepared bentonite with cement to make gel-cement it must be remembered that the bentonite requires water in addition to that used for mixing neat cement slurry and that the amount of bentonite added will govern the additional amount of water. A widely used water-cement ratio for neat cement is 5.5 gal. of water per sack of cement; but if 5 lb. of prepared bentonite is to be added to make a gel-cement, the total water content in the mix should be about 8.5 gal. per sack of cement. As is well known, the features of gel-cement are: a high angle of repose that keeps the slurry from being dissipated into porous zones or fissures and makes it desirable for recovering lost circulation or cementing thief sands; its small amount of shrinkage while setting, and the increased volume it gives to cement. Fibrous cement is also used for lost circulation and for plugging-off crevices.

Little has been done in the matter of mixing heavy material with a cement slurry to give it great weight when the cement job is to be done in a well full of especially heavy mud. One such material has been introduced and consists of a specially prepared metallic substance that has been developed to eliminate oxidation and, when added to a low water-cement ratio cement, tends to impart mobility as well as weight to the slurry.

Sand mixed with cement has been used in a number of wells in the United States but chiefly in plugging and sidetracking operations. The volume of sand used in comparison with cement ranges from 15 to 50 percent. Pea gravel has also been used for making a hard plug in the hole and as much as 20 percent of such gravel per sack of cement has been dumped down 4-in. drill pipe for this purpose.

Condition of Hole

Proper preparation of the hole for a cementing job is frequently a factor necessary for success. Electrical logging and coring will provide data on the best casing point even when circumstances make it necessary to cement a string where formations are not the most desirable. Tight places or dog-legs within the distance the cement is to extend up behind the pipe and which are discovered during the drilling of the well should be reamed or scraped to reduce the chance of channeling. Wall-scraping at and above the landing point to give an enlarged hole around the shoe has been found advantageous, especially when the hole deviates even slightly. This not only prevents contact of the cas-

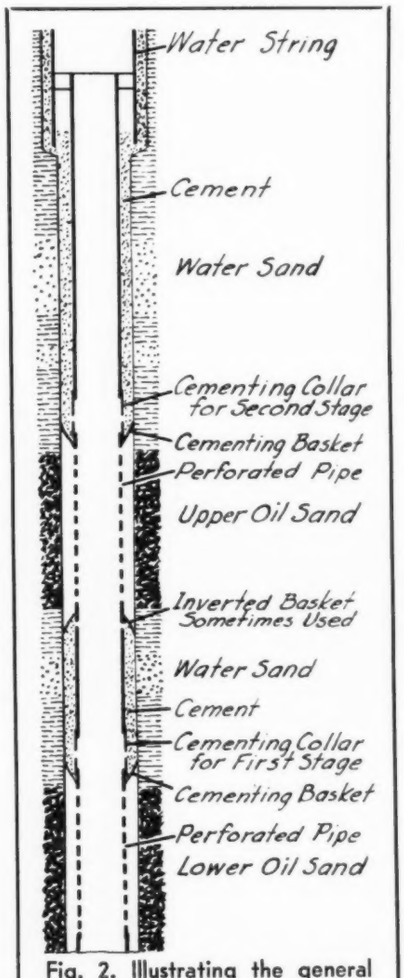
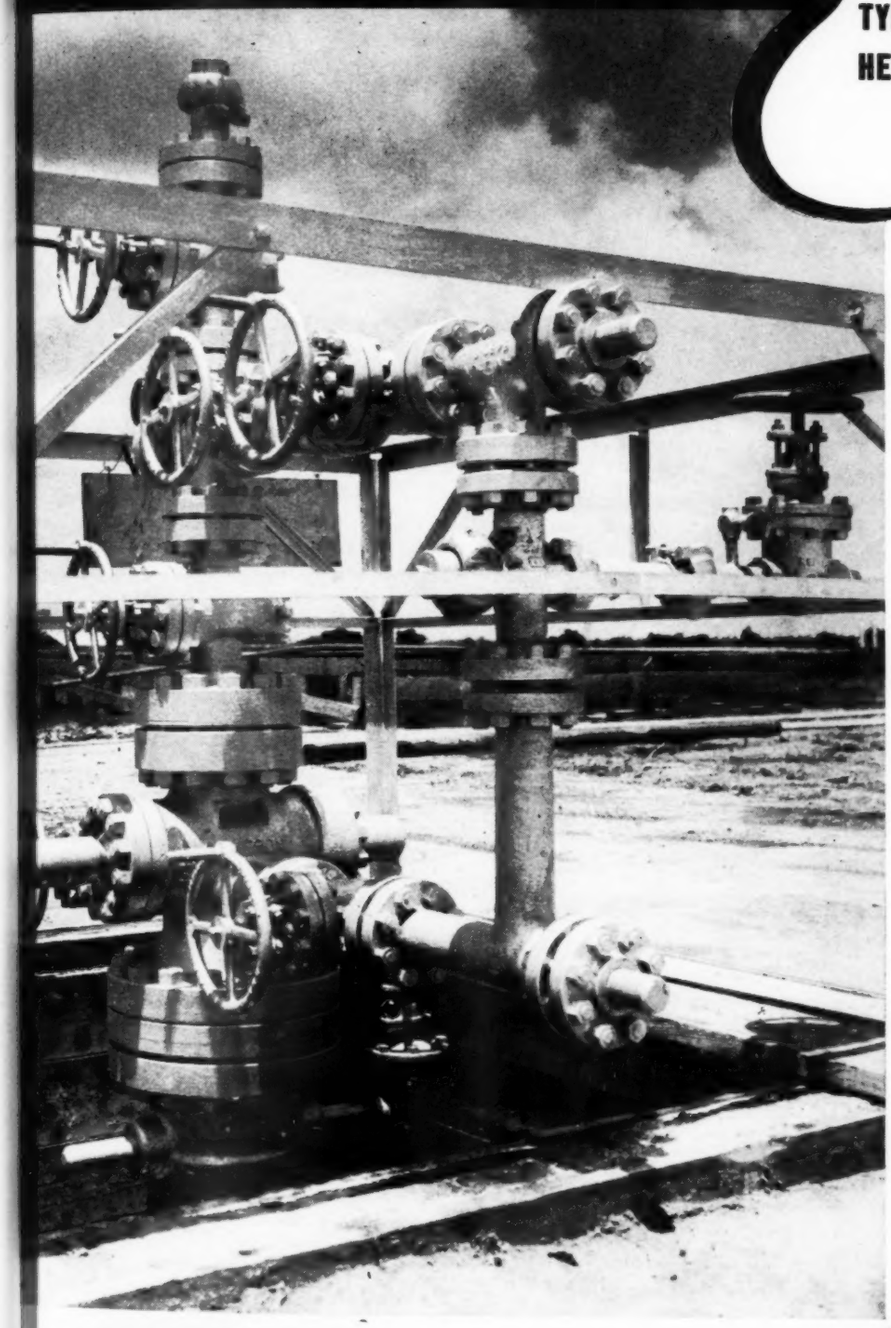


Fig. 2. Illustrating the general method used in cementing between producing zones in multiple-zone wells

CAMERON

TYPE "LD" RAM TYPE TUBING CONTROL HEAD AND TYPE "M" TEST-WELD FLANGE



This well in the Ville Platte field, Evangeline Parish, Louisiana, like numerous high pressure wells throughout the Gulf Coast, was drilled, drilled in, and completed through Cameron drilling control and completion equipment. At no time during drilling or completion operations was the well without the protection of a Cameron control unit.

But that is only part of the story. Chances are, at some future time this well will require re-working for any of a dozen possible reasons. The Cameron Type "LD" Ram Type Tubing Control Head on the well, together with an additional Cameron ram type control unit, will obviate the necessity of killing the well for re-working. Utilizing the unique Cameron hanger nipple back pressure valve and back pressure valve removing tool, the tubing may be safely raised or lowered under pressure through the two sets of rams.

At no time during the life of this well will casing pressures become equalized through failure of the casing head seal. The Cameron Type "M" Test-Weld Flange provides double assurance against pressure leaks. A heavy weld between the welding flange and oil string is the first line of defense. The plastic packing seal below the weld provides a secondary pressure-tight seal which may be safely repacked under pressure should it ever become necessary.

Thus, the 10,000 lb. test Cameron Safety Xmas Tree shown at left provides the ultimate in protection against destructive well pressures . . . present and future. Complete details on all types of Cameron completion equipment will gladly be furnished on request.

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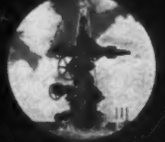

"Cameron Closed Pressure Method of Drilling and Completion" is the title of this booklet which clearly explains and illustrates, step-by-step, the modern method of drilling and completing high pressure wells. Write for your copy.

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ing with the wall at a vital point but also provides a thick plug around and above the shoe. Devices are also designed to center the casing and make sure that a uniform sheath of cement surrounds the pipe at and around the centering equipment.

Considerable attention is now being paid to the effect of the mud cake formed on the wall of the hole while drilling. This mud cake, depending in thickness on the mud-building qualities of the mud fluid, will form on any pervious formation and will generally have a detrimental effect on the cement job. It is usually difficult to remove and, in addition to interfering with the bond of the cement with the formation, will frequently start channels.

Some exclusive tests made by the Union Oil Company in California[1] have strengthened the theories of a number of engineers regarding the effect of the mud cake on cement and the means for overcoming its detrimental action. Three methods were reported as having been found "effective in removing the mud cakes:

"1. Hydraulic action by direct impingement of fluid jets (such as that induced by the down-whirler shoes) against the walls of the hole.

"2. Mechanical scraping by using suitable mechanical devices on the casing, and alternately raising and lowering the casing. This is effective only over areas where scrapers or scratchers make a bearing on the wall of the hole.

"3. Acid treatment gave best results under atmospheric pressure conditions. Laboratory tests at high pressure indicate but do not prove that effective mud cake removal under these conditions may be obtained." The mud used to form the cake for the acid treatment tests contained calcium carbonate.

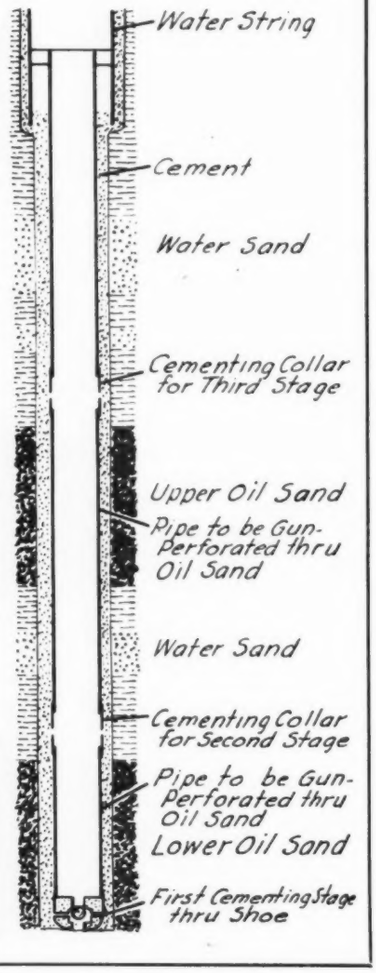
When a casing string with sufficient tensile strength is being cemented, the casing can be raised and lowered during the displacement of the slurry and there is a trend toward this practice in certain areas in the United States. Extremely high pumping velocities are also being used in many of these jobs with the object of reducing the hazard of channeling.

Casing and Liner Jobs

The surface string frequently plays a part in drilling control that warrants more consideration of the cementing of this casing than is sometimes given. Long strings run later are usually connected to the top of the surface casing, generally through landing heads, which thus becomes the anchor to resist any formation pressures encountered and to provide a means for controlling a blowout. In the majority of cases the surface string should be cemented from bottom to top and assurance made that the cement job is thorough. Some of these strings are cemented entirely around the shoe in the conventional manner whereas others are cemented partly around the shoe and the upper portion of the cement then pumped into the top.

The longer strings of casing are usually floated into the hole and are equipped with a float shoe or both a float shoe and float collar. In a few cases two float collars are used in addition to the float shoe. The float collar is set at whatever distance above the shoe the operator desires and, serving as a plug stop, allows the weak cement tailings to remain in the pipe and not settle around the hose where the best cement should be placed. The findings of the recent test cited above would indicate an advantage in using the down-whirler type of shoe that discharges the cement in a downward, spiral motion that is effective in removing the mud cake from the wall of the hole around the shoe and for some distance above. A similar, but upward, whirling action can be obtained with cementing collars used to discharge slurry at a point up the pipe for a combination job.

Fig. 3. Method employed to cement a string of blank pipe by stages



In cementing between productive strata in multiple-zone completions the operation is conducted by stages. It has been the practice in most areas to set perforated pipe opposite the oil zones with blank pipe between these perforated sections. Some operators believe, however, that it is advantageous under certain conditions to cement a blank string solidly through the entire series of productive and unproductive formations and then gun-perforate the oil horizons.

The general method being used in such multiple-zone fields as Wilmington in California is indicated in Fig. 2. A cementing collar is placed at the bottom of each blank section of pipe and the cement discharged through ports in the collar, the cementing sequence being from bottom to top. A cementing basket is usually placed below each cementing collar to protect the sand and perforations below. In some cases the inverted basket as shown is used at the top of the cementing stage to protect the upper sand and perforations when the method of cementing by stages being used permits.

The method of cementing a string of blank pipe by stages is shown in Fig. 3. Although this method has been proposed for some fields in Eastern Venezuela that have wells drilled through several producing zones, it is adaptable to any field with similar subsurface conditions, particularly where intermediate high-pressure water zones are encountered. The cementing collars are placed just above the productive zones at positions comparable to the bottom of blank sections of pipe when alternate perforated and blank sections are used. This placement of the cementing collars will insure a good, solid encasement of the pipe where it is most necessary.

Recognizing the probability of channeling and incomplete encasement of pipe with cement when the slurry must be forced to a considerable height above the shoe in long casing strings, there are definite advantages in stage cementing any long strings of pipe that depend on the cement for reinforcement and protection against corrosion.

[1] "Oil Well Cementing Factors Influencing Bond Between Cement and Formation," by P. H. Jones and Denis Berdine. Paper presented at A.P.I. Meeting, March 19, 1940, Los Angeles, California.

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT No. 40

THE tables on the following pages are designed to save time and effort for the technician, and to assist the practical field or plant worker to solve problems commonly encountered in routine work. They are not intended nor expected to supplant technical training and make every man his own designer. Most of the tables can be understood and applied by anyone acquainted with the simple fundamentals of mathematics.

For the convenience of readers who wish to refer to the tables, each page carries in the upper right corner an index number that classifies the table according to subject matter.

All petroleum engineering literature may be indexed for reference according to the Dewey Decimal System as modified and extended for the petroleum industry by L. C. Uren, professor of petroleum engineering at the University of California. When classified according to these index numbers the material follows in a logical sequence and falls into several natural divisions, as illustrated by the following outline:

Nos. P000-P339—General
Nos. P400-P499—Drilling
Nos. P500-P599—Production
Nos. P600-P699—Transportation and Storage (includes Pipe Line)
Nos. P700-P799—Refining, including
Nos. P770-P799—Natural Gasoline, which may be classified in a separate division (as shown here) if of special interest to the user.

To aid the reader in using the Decimal system, a subject index arranged alphabetically has been published, and is available from *The Petroleum Engineer*.

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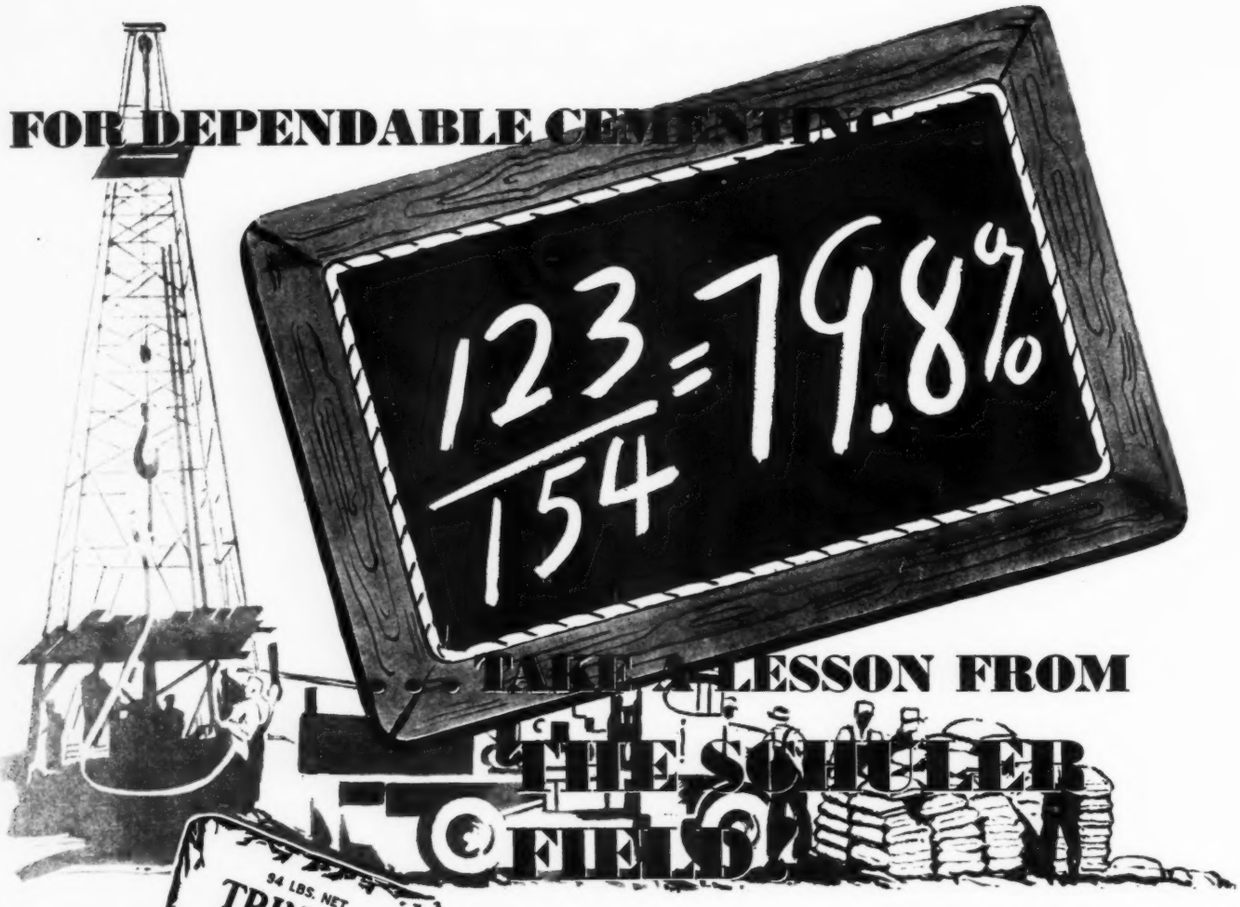
LENGTH OF TUBING STRINGS OCCUPIED BY CEMENT SLURRY

Volume of slurry formed per sack, cu. ft.	Slurry characteristics: Water content per sack, gal.	Water content per sack, cu. ft.	Water content per sack, lb.	Weight of slurry, lb. per gal.	Nominal tubing size, in.: 1¼	1½	2	2½	3	3½	4
					I.D. of tubing, in.: 1.380	1.610	1.995	2.441	2.992	3.548	3.958
					(figures below are tubing lengths in ft. occupied by a 10-sack batch)						
0.95	**3.50**	0.47	29.3	**17.4**	913	674	438	292	195	138	111
.98	**3.75**	0.50	31.3	**17.1**	942	695	452	302	201	143	115
1.01	**4.00**	0.53	33.4	**16.9**	971	716	465	311	207	147	118
1.05	**4.25**	0.57	35.5	**16.5**	1010	745	484	323	215	153	123
1.08	**4.50**	0.60	37.6	**16.3**	1038	766	498	332	221	157	126
1.11	**4.75**	0.63	39.6	**16.1**	1067	787	512	342	227	162	130
1.15	**5.00**	0.67	41.7	**15.8**	1106	816	530	354	236	167	135
1.18	**5.25**	0.70	43.8	**15.6**	1135	837	544	363	242	172	138
1.22	**5.50**	0.74	45.9	**15.3**	1173	865	562	375	250	178	143
1.25	**5.75**	0.77	48.0	**15.2**	1202	887	576	385	256	182	146
1.28	**6.00**	0.80	50.1	**15.1**	1231	908	590	394	262	186	150
1.32	**6.25**	0.84	52.2	**14.8**	1269	936	608	406	270	192	155
1.35	**6.50**	0.87	54.2	**14.7**	1298	957	622	415	277	197	158
1.38	**6.75**	0.90	56.3	**14.6**	1327	979	636	425	283	201	162
1.42	**7.00**	0.94	58.4	**14.3**	1365	1007	654	437	291	207	166
1.45	**7.25**	0.97	60.5	**14.3**	1394	1028	668	446	297	211	170
1.48	**7.50**	1.00	62.6	**14.1**	1423	1050	682	455	303	215	173
1.52	**7.75**	1.04	64.7	**14.0**	1462	1078	700	468	311	221	178
1.55	**8.00**	1.07	66.8	**13.9**	1490	1099	714	477	318	226	181
1.58	**8.25**	1.10	68.9	**13.8**	1519	1121	728	486	324	230	185
1.62	**8.50**	1.14	70.9	**13.6**	1558	1149	747	498	332	236	190
1.65	**8.75**	1.17	73.0	**13.5**	1587	1170	760	508	338	240	193
1.68	**9.00**	1.20	75.1	**13.5**	1615	1191	774	517	344	245	197
1.72	**9.25**	1.24	77.2	**13.3**	1654	1220	793	529	352	250	201
1.75	**9.50**	1.27	79.3	**13.2**	1683	1241	806	538	359	255	205
1.78	**9.75**	1.30	81.4	**13.2**	1712	1262	820	548	365	259	208
1.82	**10.0**	1.34	83.5	**13.0**	1750	1291	839	560	373	265	213
1.85	**10.25**	1.37	85.5	**13.0**	1779	1312	853	569	379	269	217
1.88	**10.5**	1.40	87.6	**12.9**	1808	1333	866	578	385	274	220
1.92	**10.75**	1.44	89.7	**12.8**	1846	1362	885	591	393	279	225
1.95	**11.0**	1.47	91.8	**12.7**	1875	1383	899	600	400	284	228
1.98	**11.25**	1.50	93.9	**12.7**	1904	1404	912	609	406	288	232
2.02	**11.5**	1.54	96.0	**12.6**	1942	1433	931	622	414	294	237
2.05	**11.75**	1.57	98.1	**12.5**	1971	1454	945	631	420	298	240
2.08	**12.0**	1.60	100.	**12.5**	2000	1475	959	640	426	303	244
2.12	**12.25**	1.64	102.	**12.4**	2038	1504	977	652	434	309	248
2.15	**12.5**	1.67	104.	**12.3**	2067	1525	991	662	441	313	252
2.18	**12.75**	1.70	106.	**12.3**	2096	1546	1005	671	447	317	255
2.22	**13.0**	1.74	109.	**12.2**	2135	1574	1023	683	455	323	260
2.25	**13.25**	1.77	111.	**12.2**	2163	1596	1037	692	461	328	263
2.28	**13.5**	1.80	113.	**12.1**	2192	1617	1051	702	467	332	267
2.32	**13.75**	1.84	115.	**12.0**	2231	1645	1069	714	475	338	272
2.35	**14.0**	1.87	117.	**12.0**	2260	1667	1083	723	482	342	275
2.38	**14.25**	1.90	119.	**12.0**	2288	1688	1097	732	488	346	279
2.42	**14.5**	1.94	121.	**11.9**	2327	1716	1115	745	496	352	283
2.45	**14.75**	1.97	123.	**11.8**	2356	1738	1129	754	502	357	287

Note: Above calculations are based on cement weighing 94 lb. per 1 cu. ft. sack. It is assumed that 1 sack of cement occupies 0.484 cu. ft. when mixed. Inclusion of data for high water-cement ratios in the lower part of the table should not be construed as a recommendation of their use when high-strength cement is desired.

FOR DEPENDABLE CEMENTING



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You, too, can depend on *Trinity* Cements. Three conveniently located plants assure prompt delivery.

TRINITY PORTLAND CEMENT COMPANY

DALLAS • FORT WORTH • HOUSTON

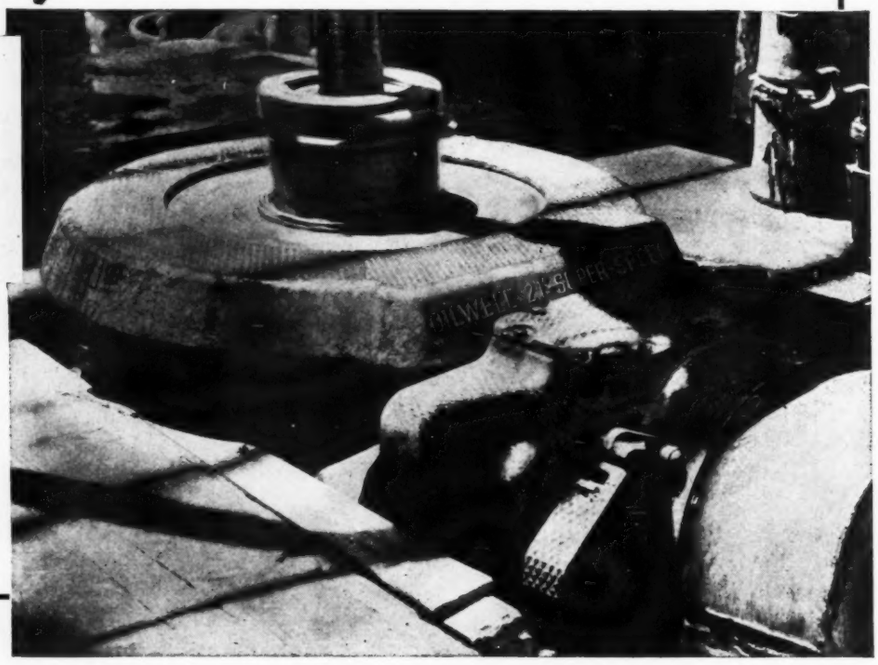
TOTAL REVOLUTIONS OF ROTARY TABLE REDUCED TO R.P.M.

Total no. of revolutions made by rotary table	Elapsed time or period of test, hr.											
	1	1½	2	2½	3	3½	4	4½	5	6	7	8
2,500	42											
3,000	50											
3,500	58											
4,000	67	44										
4,500	75	50										
5,000	83	56	42									
5,500	92	61	46									
6,000	100	67	50	40								
6,500	108	72	54	43								
7,000	117	78	58	47								
7,500	125	83	62	50	42							
8,000	133	89	67	53	44							
8,500	142	94	71	57	47	40						
9,000	150	100	75	60	50	43						
9,500	158	106	79	63	53	45						
10,000	167	111	83	67	56	48	42					
10,500	175	117	87	70	58	50	44					
11,000	183	122	92	73	61	52	46	41				
11,500	192	128	96	77	64	55	48	43				
12,000	200	133	100	80	67	57	50	44				
12,500	208	139	104	83	69	60	52	46	42			
13,000	217	144	108	87	72	62	54	48	43			
13,500	225	150	112	90	75	64	56	50	45			
14,000	233	156	117	93	78	67	58	52	47			
14,500	242	161	121	97	81	69	60	54	48	40		
15,000	250	167	125	100	83	71	63	56	50	42		
15,500	258	172	129	103	86	74	65	57	52	43		
16,000	267	178	133	107	89	76	67	59	53	44		
16,500	275	183	137	110	92	79	69	61	55	46		
17,000	283	189	142	113	94	81	71	63	57	47	40	
17,500	292	194	146	117	97	83	73	65	58	49	42	
18,000	300	200	150	120	100	86	75	67	60	50	43	
18,500	308	206	154	123	103	88	77	69	62	51	44	
19,000	317	211	158	127	106	90	79	70	63	53	45	
19,500	325	217	162	130	108	93	81	72	65	54	46	41
20,000	333	222	167	133	111	95	83	74	67	56	48	42
20,500	342	228	171	137	114	98	85	76	68	57	49	43
21,000	350	233	175	140	117	100	88	78	70	58	50	44
21,500	358	239	179	143	119	102	90	80	72	60	51	45
22,000	367	244	183	147	122	105	92	81	73	61	52	46
22,500	375	250	187	150	125	107	94	83	75	63	54	47
23,000	383	256	192	153	128	110	96	85	77	64	55	48
23,500	392	261	196	157	131	112	98	87	78	65	56	49
24,000	400	267	200	160	133	114	100	89	80	67	57	50
24,500	408	272	204	163	136	117	102	91	82	68	58	51
25,000	417	278	208	167	139	119	104	93	83	69	60	52
25,500	425	283	212	170	142	121	106	94	85	71	61	53
26,000	433	289	217	173	144	124	108	96	87	72	62	54
26,500	442	294	221	177	147	126	110	98	88	74	63	55
27,000	450	300	225	180	150	129	113	100	90	75	64	56
27,500	458	306	229	183	153	131	115	102	92	76	65	57
28,000	467	311	233	187	156	133	117	104	93	78	67	58
28,500	475	317	237	190	158	136	119	106	95	79	68	59
29,000	483	322	242	193	161	138	121	107	97	81	69	60
29,500	492	328	246	197	164	140	123	109	98	82	70	61
30,000	500	333	250	200	167	143	125	111	100	83	71	62
30,500	508	339	254	203	169	145	127	113	102	85	73	64
31,000	517	344	258	207	172	148	129	115	103	86	74	65
31,500	525	350	262	210	175	150	131	117	105	88	75	66
32,000	533	356	267	213	178	152	133	119	107	89	76	67

See footnote of tables indexed P 425.262.

Faster Speeds FOR ROTARIES!

"OILWELL"
SUPER-SPEED UNITS OPERATE ON BANTAM ANGULAR CONTACT BEARINGS



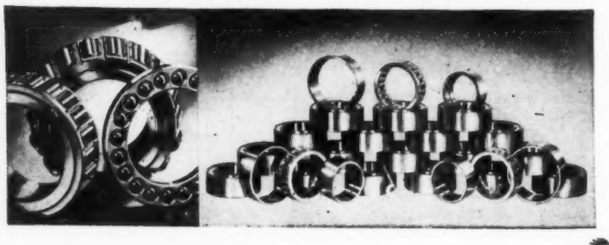
New highs in table speeds are possible with Oil Well Supply Company's new Super-Speed Rotaries. Meeting the demand for faster drilling, "Oilwell" has designed these ultra-modern units to operate successfully at the exceptionally high speed of 1000 RPM.

For these high-speed rotaries "Oilwell" naturally selected Bantam Angular Contact Bearings—for these bearings have been a major factor in making high table speeds possible. Their unique design enables them to take both the thrust load and the radial load imposed by driving gear and rotating weight. Extremely accurate hardening and grinding insure the proper contact for efficient operation.

This is a typical instance of the way in which Bantam's engineering skill aids the maker of oil well equipment to anticipate the needs of his customers. You, too, can profit by Bantam's skill—by specifying Bantam Bearings when you buy equipment.

BANTAM BEARINGS CORPORATION • SOUTH BEND, INDIANA

BANTAM'S ENGINEERING COUNSEL is based on comprehensive experience—on thorough knowledge of the performance records of *every* type of bearing. For unbiased advice on type of bearing adapted to specific service conditions, more and more manufacturers TURN TO BANTAM.



(*Far Left*) **TAPERED ROLLER, STRAIGHT ROLLER, AND BALL BEARINGS** — Bantam's wide line of bearings includes every major anti-friction type—Bantam engineers recommend the bearing that best suits your specific needs.

(*Left*) **BANTAM'S JOURNAL ROLLER BEARINGS** find wide use in the oil fields, especially for radial loads beyond the range of Quill Bearings. Crown blocks, traveling blocks, swivels, drawworks, and rotary drives are a few typical applications.

BANTAM BEARINGS
STRAIGHT ROLLER • TAPERED ROLLER • NEEDLE • BALL

SAPONIFICATION NUMBERS—OILS CONTAINING MORE THAN 30% FATTY OILS—METHOD A

D = 15.0 to 19.9

Value of D[1]	Weight of oil sample, w, grams.																				
	4.90	4.91	4.92	4.93	4.94	4.95	4.96	4.97	4.98	4.99	5.00	5.01	5.02	5.03	5.04	5.05	5.06	5.07	5.08	5.09	5.10
15.0	85.9	85.7	85.5	85.3	85.2	85.0	84.8	84.7	84.5	84.3	84.2	84.0	83.8	83.6	83.5	83.3	83.2	83.0	82.8	82.7	82.5
15.1	86.4	86.3	86.1	85.9	85.7	85.6	85.4	85.2	85.1	84.9	84.7	84.5	84.4	84.2	84.0	83.9	83.7	83.5	83.4	83.2	83.1
15.2	87.0	86.8	86.7	86.5	86.3	86.1	86.0	85.8	85.6	85.4	85.3	85.1	84.9	84.8	84.6	84.4	84.3	84.1	83.9	83.8	83.6
15.3	87.6	87.4	87.2	87.1	86.9	86.7	86.5	86.4	86.2	86.0	85.8	85.7	85.5	85.3	85.2	85.0	84.8	84.6	84.5	84.3	84.2
15.4	88.2	88.0	87.8	87.6	87.4	87.3	87.1	86.9	86.7	86.6	86.4	86.2	86.0	85.9	85.7	85.5	85.4	85.2	85.0	84.9	84.7
15.5	88.7	88.5	88.4	88.2	88.0	87.8	87.7	87.5	87.3	87.1	87.0	86.8	86.6	86.4	86.3	86.1	85.9	85.8	85.6	85.4	85.3
15.6	89.3	89.1	88.9	88.8	88.6	88.4	88.2	88.0	87.9	87.7	87.5	87.3	87.2	87.0	86.8	86.7	86.5	86.3	86.1	86.0	85.8
15.7	89.9	89.7	89.5	89.3	89.1	89.0	88.8	88.6	88.4	88.3	88.1	87.9	87.7	87.6	87.4	87.2	87.0	86.9	86.7	86.5	86.4
15.8	90.4	90.3	90.1	89.9	89.7	89.5	89.4	89.2	89.0	88.8	88.6	88.5	88.3	88.1	87.9	87.8	87.6	87.4	87.2	87.1	86.9
15.9	91.0	90.8	90.6	90.5	90.3	90.1	89.9	89.7	89.6	89.4	89.2	89.0	88.8	88.7	88.5	88.3	88.1	88.0	87.8	87.6	87.5
16.0	91.6	91.4	91.2	91.0	90.8	90.7	90.5	90.3	90.1	89.9	89.8	89.6	89.4	89.2	89.0	88.9	88.7	88.5	88.3	88.2	88.0
16.1	92.2	92.0	91.8	91.6	91.4	91.2	91.0	90.9	90.7	90.5	90.3	90.1	90.0	89.8	89.6	89.4	89.3	89.1	88.9	88.7	88.6
16.2	92.7	92.5	92.4	92.2	92.0	91.8	91.6	91.4	91.2	91.1	90.9	90.7	90.5	90.3	90.2	90.0	89.8	89.6	89.5	89.3	89.1
16.3	93.3	93.1	92.9	92.7	92.6	92.4	92.2	92.0	91.8	91.6	91.4	91.3	91.1	90.9	90.7	90.5	90.4	90.2	90.0	89.8	89.7
16.4	93.9	93.7	93.5	93.3	93.1	92.9	92.7	92.6	92.4	92.2	92.0	91.8	91.6	91.5	91.3	91.1	90.9	90.7	90.6	90.4	90.2
16.5	94.5	94.3	94.1	93.9	93.7	93.5	93.3	93.1	92.9	92.7	92.6	92.4	92.2	92.0	91.8	91.6	91.5	91.3	91.1	90.9	90.8
16.6	95.0	94.8	94.6	94.4	94.3	94.1	93.9	93.7	93.5	93.3	93.1	92.9	92.8	92.6	92.4	92.2	92.0	91.8	91.7	91.5	91.3
16.7	95.6	95.4	95.2	95.0	94.8	94.6	94.4	94.3	94.1	93.9	93.7	93.5	93.3	93.1	92.9	92.8	92.6	92.4	92.2	92.0	91.9
16.8	96.2	96.0	95.8	95.6	95.4	95.2	95.0	94.8	94.6	94.4	94.2	94.1	93.9	93.7	93.5	93.3	93.1	92.9	92.8	92.6	92.4
16.9	96.7	96.5	96.4	96.2	96.0	95.8	95.6	95.4	95.2	95.0	94.8	94.6	94.4	94.2	94.1	93.9	93.7	93.5	93.3	93.1	93.0
17.0	97.3	97.1	96.9	96.7	96.5	96.3	96.1	95.9	95.8	95.6	95.4	95.2	95.0	94.8	94.6	94.4	94.2	94.1	93.9	93.7	93.5
17.1	97.9	97.7	97.5	97.3	97.1	96.9	96.7	96.5	96.3	96.1	95.9	95.7	95.5	95.4	95.2	95.0	94.8	94.6	94.4	94.2	94.1
17.2	98.5	98.3	98.1	97.9	97.7	97.5	97.3	97.1	96.9	96.7	96.5	96.3	96.1	95.9	95.7	95.5	94.3	95.2	95.0	94.8	94.6
17.3	99.0	98.8	98.6	98.4	98.2	98.0	97.8	97.6	97.4	97.2	97.1	96.9	96.7	96.5	96.3	96.1	95.9	95.7	95.5	95.3	95.2
17.4	99.6	99.4	99.2	99.0	98.8	98.6	98.4	98.2	98.0	97.8	97.6	97.4	97.2	97.0	96.8	96.6	96.5	96.3	96.1	95.9	95.7
17.5	100.	100.	99.7	100.	99.4	99.2	99.0	98.8	98.6	98.4	98.2	98.0	97.8	97.6	97.4	97.2	97.0	96.8	96.6	96.4	96.3
17.6	101.	101.	100.	100.	100.	99.7	99.5	99.3	99.1	98.9	98.7	98.5	98.3	98.1	98.0	97.8	97.6	97.4	97.2	97.0	96.8
17.7	101.	101.	101.	101.	101.	100.	100.	99.9	99.7	99.5	99.3	99.1	98.9	98.7	98.5	98.3	98.1	97.9	97.7	97.5	97.4
17.8	102.	102.	101.	101.	101.	101.	101.	100.	100.	100.	100.	99.7	99.5	99.3	99.1	98.9	98.7	98.5	98.3	98.1	97.9
17.9	102.	102.	102.	102.	102.	101.	101.	101.	101.	101.	100.	100.	100.	99.8	99.6	99.4	99.2	99.0	98.8	98.6	98.5
18.0	103.	103.	103.	102.	102.	102.	102.	102.	101.	101.	101.	101.	101.	100.	100.	100.	99.8	99.6	99.4	99.2	99.0
18.1	104.	103.	103.	103.	103.	103.	102.	102.	102.	102.	102.	101.	101.	101.	101.	101.	100.	100.	99.9	99.7	99.6
18.2	104.	104.	104.	104.	103.	103.	103.	103.	103.	102.	102.	102.	102.	101.	101.	101.	101.	101.	100.	100.	100.
18.3	105.	105.	104.	104.	104.	104.	103.	103.	103.	103.	103.	102.	102.	102.	102.	102.	101.	101.	101.	101.	101.
18.4	105.	105.	105.	105.	104.	104.	104.	104.	104.	103.	103.	103.	103.	103.	102.	102.	102.	102.	102.	101.	101.
18.5	106.	105.	105.	105.	105.	105.	105.	104.	104.	104.	104.	104.	103.	103.	103.	103.	103.	102.	102.	102.	102.
18.6	106.	106.	106.	106.	106.	105.	105.	105.	105.	105.	104.	104.	104.	104.	104.	103.	103.	103.	103.	103.	102.
18.7	107.	107.	107.	106.	106.	106.	106.	106.	105.	105.	105.	105.	104.	104.	104.	104.	104.	103.	103.	103.	103.
18.8	108.	107.	107.	107.	107.	107.	106.	106.	106.	106.	105.	105.	105.	105.	105.	104.	104.	104.	104.	104.	103.
18.9	108.	108.	108.	108.	107.	107.	107.	107.	106.	106.	106.	106.	106.	105.	105.	105.	105.	105.	104.	104.	104.
19.0	109.	109.	108.	108.	108.	108.	107.	107.	107.	107.	107.	106.	106.	106.	106.	106.	106.	105.	105.	105.	105.
19.1	109.	109.	109.	109.	109.	108.	108.	108.	108.	107.	107.	107.	107.	107.	106.	106.	106.	106.	105.	105.	105.
19.2	110.	110.	109.	109.	110.	109.	109.	108.	108.	108.	108.	107.	107.	107.	107.	107.	106.	106.	106.	106.	106.
19.3	110.	110.	110.	110.	110.	109.	109.	109.	109.	108.	108.	108.	108.	108.	107.	107.	107.	107.	107.	106.	106.
19.4	111.	111.	111.	111.	111.	110.	110.	109.	109.	109.	109.	109.	108.	108.	108.	108.	108.	107.	107.	107.	107.
19.5	112.	111.	111.	111.	111.	111.	110.	110.	110.	110.	109.	109.	109.	109.	109.	108.	108.	108.	108.	107.	107.
19.6	112.	112.	112.	112.	112.	111.	111.	111.	110.	110.	110.	110.	110.	109.	109.	109.	109.	108.	108.	108.	108.
19.7	113.	113.	112.	112.	112.	112.	111.	111.	111.	111.	111.	110.	110.	110.	110.	109.	109.	109.	109.	109.	108.
19.8	113.	113.	113.	113.	113.	112.	112.	112.	112.	111.	111.	111.	111.	110.	110.	110.	110.	110.	109.	109.	109.
19.9	114.	114.	113.	113.	114.	113.	113.	112.	112.	112.	112.	111.	111.	111.	111.	111.	110.	110.	110.	110.	109.

[1] D = difference between the number of milliliters of 0.5*N* HCl required for the determination and the average of the two blanks run on the alcoholic potassium hydroxide solution.

The above saponification numbers are calculated by the formula: $\text{Saponification number} = \frac{D \times 28.05}{w}$

This formula is from "Test for Saponification Number," A.S.T.M. (D94-39T).

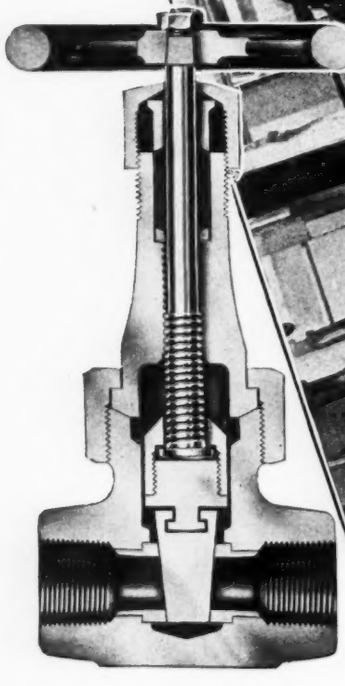
For additional notes, see tables indexed P 747.501.10.

Chapman List 960

FORGED STEEL GATE VALVES

For All Small Valve Work

Chapman List 960 Valves on the instrument board connections of a Houdry Unit, Socony Vacuum Oil Co.



Sectional View
Inside Screw Model
Chapman List 960
Steel Gate Valve

Chapman List 960 Steel Gate Valves are tough, all-purpose valves designed to eliminate small valve troubles on all types of service applications. They are made in sizes from ¼" to 2", *inside* or *outside* screws, for pressures up to 800 lbs. at 750° F., or 1500 lbs. cold working pressure. We recommend them for real economy, long life and unfailing service.

THE CHAPMAN VALVE
Manufacturing Company
INDIAN ORCHARD, MASS.

DRILLING RATES AND TABLE SPEEDS CONVERTED TO FT. DRILLED PER 1000 REVOLUTIONS

100-145 r.p.m.

Drilling rate			Speed of rotary table, r.p.m.									
ft. per hr.	ft. per min.	min. per ft.	100	105	110	115	120	125	130	135	140	145
1	0.02	60	0.17	0.16	0.15	0.14	0.14	0.13	0.13	0.12	0.12	0.11
2	.03	30	0.33	0.32	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.23
3	.05	20	0.50	0.48	0.46	0.43	0.42	0.40	0.38	0.37	0.36	0.34
4	.07	15	0.67	0.64	0.61	0.58	0.56	0.53	0.51	0.49	0.48	0.46
5	.08	12	0.83	0.79	0.76	0.72	0.69	0.67	0.64	0.62	0.60	0.57
6	0.10	10	1.00	0.95	0.91	0.87	0.83	0.80	0.77	0.74	0.71	0.69
7	.12	8.6	1.17	1.11	1.06	1.01	0.97	0.93	0.90	0.86	0.83	0.80
8	.13	7.5	1.33	1.27	1.21	1.16	1.11	1.07	1.03	0.99	0.95	0.92
9	.15	6.7	1.50	1.43	1.36	1.30	1.25	1.20	1.15	1.11	1.07	1.03
10	.17	6.0	1.67	1.59	1.52	1.45	1.39	1.33	1.28	1.23	1.19	1.15
11	0.18	5.5	1.83	1.75	1.67	1.59	1.53	1.47	1.41	1.36	1.31	1.26
12	.20	5.0	2.00	1.90	1.82	1.74	1.67	1.60	1.54	1.48	1.43	1.38
13	.22	4.6	2.17	2.06	1.97	1.88	1.81	1.73	1.67	1.60	1.55	1.49
14	.23	4.3	2.33	2.22	2.12	2.03	1.94	1.87	1.79	1.73	1.67	1.61
15	.25	4.0	2.50	2.38	2.27	2.17	2.08	2.00	1.92	1.85	1.79	1.72
16	0.27	3.8	2.67	2.54	2.42	2.32	2.22	2.13	2.05	1.98	1.90	1.84
17	.28	3.5	2.83	2.70	2.58	2.46	2.36	2.27	2.18	2.10	2.02	1.95
18	.30	3.3	3.00	2.86	2.73	2.61	2.50	2.40	2.31	2.22	2.14	2.07
19	.32	3.2	3.17	3.02	2.88	2.75	2.64	2.53	2.44	2.35	2.26	2.18
20	.33	3.0	3.33	3.17	3.03	2.90	2.78	2.67	2.56	2.47	2.38	2.30
25	0.42	2.4	4.17	3.97	3.79	3.62	3.47	3.33	3.21	3.09	2.98	2.87
30	.50	2.0	5.00	4.76	4.55	4.35	4.17	4.00	3.85	3.70	3.57	3.45
35	.58	1.7	5.83	5.56	5.30	5.07	4.86	4.67	4.49	4.32	4.17	4.02
40	.67	1.5	6.67	6.35	6.06	5.80	5.56	5.33	5.13	4.94	4.76	4.60
45	.75	1.3	7.50	7.14	6.82	6.52	6.25	6.00	5.77	5.56	5.36	5.17
50	0.83	1.2	8.33	7.94	7.58	7.25	6.94	6.67	6.41	6.17	5.95	5.75
55	.92	1.1	9.17	8.73	8.33	7.97	7.64	7.33	7.05	6.79	6.55	6.32
60	1.00	1.0	10.0	9.52	9.09	8.70	8.33	8.00	7.69	7.41	7.14	6.90
65	1.1	0.92	10.8	10.3	9.85	9.42	9.03	8.67	8.33	8.02	7.74	7.47
70	1.2	.86	11.7	11.1	10.6	10.1	9.72	9.33	8.97	8.64	8.33	8.05
75	1.25	0.80	12.5	11.9	11.4	10.9	10.4	10.0	9.62	9.26	8.93	8.62
80	1.33	.75	13.3	12.7	12.1	11.6	11.1	10.7	10.3	9.88	9.52	9.20
85	1.4	.71	14.2	13.5	12.9	12.3	11.8	11.3	10.9	10.5	10.1	9.77
90	1.50	.67	15.0	14.3	13.6	13.0	12.5	12.0	11.5	11.1	10.7	10.3
95	1.6	.63	15.8	15.1	14.4	13.8	13.2	12.7	12.2	11.7	11.3	10.9
100	1.67	0.60	16.7	15.9	15.2	14.5	13.9	13.3	12.8	12.3	11.9	11.5
105	1.75	.57	17.5	16.7	15.9	15.2	14.6	14.0	13.5	13.0	12.5	12.1
110	1.8	.55	18.3	17.5	16.7	15.9	15.3	14.7	14.1	13.6	13.1	12.6
115	1.9	.52	19.2	18.3	17.4	16.7	16.0	15.3	14.7	14.2	13.7	13.2
120	2.00	.50	20.0	19.0	18.2	17.4	16.7	16.0	15.4	14.8	14.3	13.8
125	2.1	0.48	20.8	19.8	18.9	18.1	17.4	16.7	16.0	15.4	14.9	14.4
130	2.2	.46	21.7	20.6	19.7	18.8	18.1	17.3	16.7	16.0	15.5	14.9
135	2.25	.44	22.5	21.4	20.5	19.6	18.8	18.0	17.3	16.7	16.1	15.5
140	2.33	.43	23.3	22.2	21.2	20.3	19.4	18.7	17.9	17.3	16.7	16.1
145	2.4	.41	24.2	23.0	22.0	21.0	20.1	19.3	18.6	17.9	17.3	16.7
150	2.50	0.40	25.0	23.8	22.7	21.7	20.8	20.0	19.2	18.5	17.9	17.2
155	2.6	.39	25.8	24.6	23.5	22.5	21.5	20.7	19.9	19.1	18.5	17.8
160	2.67	.38	26.7	25.4	24.2	23.2	22.2	21.3	20.5	19.8	19.0	18.4
165	2.75	.36	27.5	26.2	25.0	23.9	22.9	22.0	21.2	20.4	19.6	19.0
170	2.8	.35	28.3	27.0	25.8	24.6	23.6	22.7	21.8	21.0	20.2	19.5
175	2.9	0.34	29.2	27.8	26.5	25.4	24.3	23.3	22.4	21.6	20.8	20.1
180	3.00	.33	30.0	28.6	27.3	26.1	25.0	24.0	23.1	22.2	21.4	20.7
185	3.1	.32	30.8	29.4	28.0	26.8	25.7	24.7	23.7	22.8	22.0	21.3
190	3.2	.32	31.7	30.2	28.8	27.5	26.4	25.3	24.4	23.5	22.6	21.8
195	3.25	.31	32.5	31.0	29.5	28.3	27.1	26.0	25.0	24.1	23.2	22.4

Because of the increasing tendency among drilling engineers to correlate drilling rates with table speeds and express drilling speeds in the more reliable terms of ft. drilled per revolution of the rotary table, this table has been designed to aid in the more rapid conversion of the recorded data.

Equipment Manufacturers and Operators Prefer Diamond Roller Chains

● Along with the advances in oil field machinery developments, the need for greater speeds, deeper holes, higher efficiencies—DIAMOND Roller Chains for drilling, pumping, and servicing power rigs, for winches, tractors, trenchers, etc. have more than met the changing requirements of the last 20 years.

● Leading manufacturers of equipment and experienced operators well know that DIAMOND Drives are the "Preferred Power Drives" of the industry,—that they have demonstrated their reserve power, high power transmitting efficiency, dependability, and ease of application and maintenance. They are used in all the important oil fields of the United States and the world,—used more extensively than any other drive chain...

DIAMOND CHAIN & MFG. CO., 441 Kentucky Ave., Indianapolis, Indiana
Tulsa Office: 2238 Terwilleger Blvd

DIAMOND ROLLER CHAINS

50th Anniversary *1890-1940*

IT'S THE DRIVE YOU USE THAT MAKES THE DIFFERENCE

TOTAL ENGINE CYLINDER CYCLES PER 24-HR. DAY

Engine speed, r.p.m.	No. of cylinders									
	1	2	3	4	5	6	8	10	12	16
1	1,440	2,880	4,320	5,760	7,200	8,640	11,520	14,400	17,280	23,040
2	2,880	5,760	8,640	11,520	14,400	17,280	23,040	28,800	34,560	46,080
3	4,320	8,640	12,960	17,280	21,600	25,920	34,560	43,200	51,840	69,120
4	5,760	11,520	17,280	23,040	28,800	34,560	46,080	57,600	69,120	92,160
5	7,200	14,400	21,600	28,800	36,000	43,200	57,600	72,000	86,400	115,200
6	8,640	17,280	25,920	34,560	43,200	51,840	69,120	86,400	103,680	138,240
7	10,080	20,160	30,240	40,320	50,400	60,480	80,640	100,800	120,960	161,280
8	11,520	23,040	34,560	46,080	57,600	69,120	92,160	115,200	138,240	184,320
9	12,960	25,920	38,880	51,840	64,800	77,760	103,680	129,600	155,520	207,360
10	14,400	28,800	43,200	57,600	72,000	86,400	115,200	144,000	172,800	230,400
20	28,800	57,600	86,400	115,200	144,000	172,800	230,400	288,000	345,600	460,800
30	43,200	86,400	129,600	172,800	216,000	259,200	345,600	432,000	518,400	691,200
40	57,600	115,200	172,800	230,400	288,000	345,600	460,800	576,000	691,200	921,600
50	72,000	144,000	216,000	288,000	360,000	432,000	576,000	720,000	864,000	1,152,000
60	86,400	172,800	259,200	345,600	432,000	518,400	691,200	864,000	1,036,800	1,382,400
70	100,800	201,600	302,400	403,200	504,000	604,800	806,400	1,008,000	1,209,600	1,612,800
80	115,200	230,400	345,600	460,800	576,000	691,200	921,600	1,152,000	1,382,400	1,843,200
90	129,600	259,200	388,800	518,400	648,000	777,600	1,036,800	1,296,000	1,555,200	2,073,600
100	144,000	288,000	432,000	576,000	720,000	864,000	1,152,000	1,440,000	1,728,000	2,304,000
110	158,400	316,800	475,200	633,600	792,000	950,400	1,267,200	1,584,000	1,900,800	2,534,400
120	172,800	345,600	518,400	691,200	864,000	1,036,800	1,382,400	1,728,000	2,073,600	2,764,800
130	187,200	374,400	561,600	748,800	936,000	1,123,200	1,497,600	1,872,000	2,246,400	2,995,200
140	201,600	403,200	604,800	806,400	1,008,000	1,209,600	1,612,800	2,016,000	2,419,200	3,225,600
150	216,000	432,000	648,000	864,000	1,080,000	1,296,000	1,728,000	2,160,000	2,592,000	3,456,000
160	230,400	460,800	691,200	921,600	1,152,000	1,382,400	1,843,200	2,304,000	2,764,800	3,686,400
170	244,800	489,600	734,400	979,200	1,224,000	1,468,800	1,958,400	2,448,000	2,937,600	3,916,800
180	259,200	518,400	777,600	1,036,800	1,296,000	1,555,200	2,073,600	2,592,000	3,110,400	4,147,200
190	273,600	547,200	820,800	1,094,400	1,368,000	1,641,600	2,188,800	2,736,000	3,282,200	4,377,600
200	288,000	576,000	864,000	1,152,000	1,440,000	1,728,000	2,304,000	2,880,000	3,456,000	4,608,000
210	302,400	604,800	907,200	1,209,600	1,512,000	1,814,400	2,419,200	3,024,000	3,628,800	4,838,400
220	316,800	633,600	950,400	1,267,200	1,584,000	1,900,800	2,534,400	3,168,000	3,801,600	5,068,800
230	331,200	662,400	993,600	1,324,800	1,656,000	1,987,200	2,649,600	3,312,000	3,974,400	5,299,200
240	345,600	691,200	1,036,800	1,382,400	1,728,000	2,073,600	2,764,800	3,456,000	4,147,200	5,529,600
250	360,000	720,000	1,080,000	1,440,000	1,800,000	2,160,000	2,880,000	3,600,000	4,320,000	5,760,000
260	374,400	748,800	1,123,200	1,497,600	1,872,000	2,246,400	2,995,200	3,744,000	4,492,800	5,990,400
270	388,800	777,600	1,166,400	1,555,200	1,944,000	2,332,800	3,110,400	3,888,000	4,665,600	6,220,880
280	403,200	806,400	1,209,600	1,612,800	2,016,000	2,419,200	3,225,600	4,032,000	4,838,400	6,451,200
290	417,600	835,200	1,252,800	1,670,400	2,088,000	2,505,600	3,340,800	4,176,000	5,011,200	6,681,600
300	432,000	864,000	1,296,000	1,728,000	2,160,000	2,592,000	3,456,000	4,320,000	5,184,000	6,912,000
310	446,400	892,800	1,339,200	1,785,600	2,232,000	2,678,400	3,571,200	4,464,000	5,356,800	7,142,400
320	460,800	921,600	1,382,400	1,843,200	2,304,000	2,764,800	3,686,400	4,608,000	5,529,600	7,372,800
330	475,200	950,400	1,425,600	1,900,800	2,376,000	2,851,200	3,801,600	4,752,000	5,702,400	7,603,200
340	489,600	979,200	1,468,800	1,958,400	2,448,000	2,937,600	3,916,800	4,896,000	5,875,200	7,833,600
350	504,000	1,008,000	1,512,000	2,016,000	2,520,000	3,024,000	4,032,000	5,040,000	6,048,000	8,064,000
360	518,400	1,036,800	1,555,200	2,073,600	2,592,000	3,110,400	4,147,200	5,184,000	6,220,800	8,294,400
370	532,800	1,065,600	1,598,400	2,131,200	2,664,000	3,196,800	4,262,400	5,328,000	6,393,600	8,524,800
380	547,200	1,094,400	1,641,600	2,188,800	2,736,000	3,283,200	4,377,600	5,472,000	6,566,400	8,755,200
390	561,600	1,123,200	1,684,800	2,246,400	2,808,000	3,369,600	4,992,800	5,616,000	6,739,200	8,985,600
400	576,000	1,152,000	1,728,000	2,304,000	2,880,000	3,456,000	4,608,000	5,760,000	6,912,000	9,216,000
500	720,000	1,440,000	2,160,000	2,880,000	3,600,000	4,320,000	5,760,000	7,200,000	8,640,000	11,520,000
600	864,000	1,728,000	2,592,000	3,456,000	4,320,000	5,184,000	6,912,000	8,640,000	10,368,000	13,824,000
700	1,008,000	2,016,000	3,024,000	4,032,000	5,040,000	6,048,000	8,064,000	10,080,000	12,096,000	16,128,000
800	1,152,000	2,304,000	3,456,000	4,608,000	5,760,000	6,912,000	9,216,000	11,520,000	13,824,000	18,432,000
900	1,296,000	2,592,000	3,888,000	5,184,000	6,480,000	7,776,000	10,368,000	12,960,000	15,552,000	20,736,000
1000	1,440,000	2,880,000	4,320,000	5,760,000	7,200,000	8,640,000	11,520,000	14,400,000	17,280,000	23,040,000

Example: A 4-cylinder engine operates 12 hours at an average speed of 625 r.p.m. and 12 hr. at an average speed of 615 r.p.m. What is total number of cycles made by all cylinders of the engine in the 24-hr. period?

Solution:

Average speed = (625 + 615) ÷ 2 = 620 r.p.m.

From table:

A 4-cylinder engine at 600 r.p.m. = 3,456,000 cycles
at 20 r.p.m. = 115,200

Total for engine = **3,571,200** cycles

Note: A cycle represents the two strokes made by the piston during each revolution of the crankshaft.

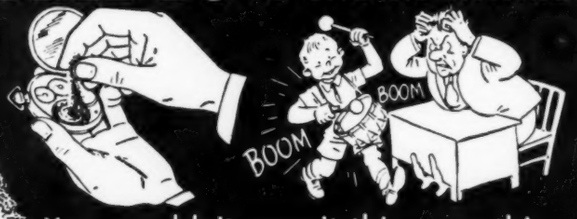
Keep Engines Running

at Maximum Output—with Minimum Trouble

American Industry faces the most crucial test in years. Production facilities will be strained to the utmost as governmental and civilian orders pile up. Production equipment must be at peak efficiency.

Be sure all internal combustion engines, compressors and pumps are equipped for maximum output, minimum maintenance. Equip each one NOW with Protectomotor Intake Filters. Stop trouble where it frequently starts —in abrasive dust that wears reciprocating parts and clogs valves, reducing production as it increases chances for trouble. Be ready, America—equip with Protectomotors NOW!

MODEL DS SILENCES, FILTERS AIR TO ENGINE INTAKE



You wouldn't permit this . . . or this . . .

WHY LET UNPROTECTED ENGINE INTAKES DRAW IN DUST . . . . . CAUSE EXCESSIVE NOISE?

The Model DS Protectomotor is the only device that not only prevents the intake of dust to air-breathing machines, but also silences the intake sound. It provides constant efficiency throughout operating period and less restriction than any other air filter.

Construction is simple, rugged and effective, possessing many exclusive, patented features and special advantages.

A. Series of cylindrical rectifying chambers of scientific diameter to length ratio which smooths out sound waves.
B. Dry Feltex Filtering Medium 99.8% efficient by University of California Laboratory tests.
C. Radial Fin Construction. Permits large area of filtering medium to occupy smallest possible space.
D. Rigid, galvanized mesh frame.
E. Reinforcing tube. The Model DS Protectomotor is "built like a battleship."

← MODEL D INTAKE FILTER extensively used on intake of engines and compressors where noise elimination is not important. Same construction as Model DS except for silencing features.

WRITE FOR CATALOG describing filters for engines, pipe lines, ventilation, etc.

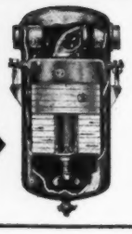
STAYNEW FILTER CORP.

"Air Filter Headquarters"

2 Leighton Ave. Rochester, N. Y.

PROTECTOMOTOR AIR FILTERS 99 and Per Cent Efficient

NEW→



SLIGHTEST TRACES OF OIL REMOVED FROM AIR TRANSMISSION LINES WITH LATEST PROTECTOMOTOR, MODEL AAPHS PIPE LINE FILTER. Staynew engineers have designed an entirely new type of pipe line filter, now used extensively for the protection of delicate air-powered control devices. This new filter, the Model AAPHS, prevents passage of the most minute traces of vaporized oil. The AAPHS is actually a "super" filter, used in most applications as the final of two or more stages of filtration.

Construction Features: (1) inlet; (2) baffle; (3) Solid Feltex Discs through which all air must pass; (4) carrier tube; (5) outlet; (6) shell; (7) drain cock.

Static Press.
400-495 lb.

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																			
	400	405	410	415	420	425	430	435	440	445	450	455	460	465	470	475	480	485	490	495
2	28.79	28.96	29.14	29.30	29.47	29.64	29.81	29.98	30.15	30.30	30.47	30.64	30.80	30.97	31.12	31.28	31.45	31.60	31.76	31.91
4	40.72	40.96	41.22	41.44	41.68	41.92	42.16	42.40	42.64	42.86	43.10	43.34	43.56	43.80	44.02	44.22	44.48	44.70	44.92	45.14
6	49.86	50.16	50.47	50.74	51.04	51.33	51.62	51.92	52.21	52.48	52.78	53.07	53.34	53.63	53.90	54.17	54.47	54.74	55.00	55.27
8	57.58	57.92	58.29	58.60	58.94	59.27	59.61	59.95	60.29	60.60	60.94	61.28	61.59	61.93	62.24	62.56	62.89	63.21	63.52	63.83
10	64.38	64.76	65.17	65.52	65.90	66.28	66.65	67.03	67.41	67.76	68.14	68.52	68.87	69.25	69.60	69.94	70.32	70.67	71.02	71.37
12	70.53	70.94	71.39	71.77	72.19	72.61	73.02	73.44	73.85	74.23	74.65	75.06	75.45	75.86	76.24	76.62	77.04	77.42	77.80	78.18
14	76.19	76.64	77.12	77.53	77.98	78.43	78.88	79.33	79.78	80.19	80.64	81.09	81.50	81.95	82.36	82.77	83.22	83.63	84.05	84.46
16	81.44	81.92	82.44	82.88	83.36	83.84	84.32	84.80	85.28	85.72	86.20	86.68	87.12	87.60	88.04	88.48	88.96	89.40	89.84	90.28
18	86.39	86.90	87.45	87.91	88.42	88.93	89.44	89.95	90.46	90.93	91.44	91.95	92.41	92.92	93.39	93.86	94.36	94.83	95.30	95.76
20	91.05	91.59	92.17	92.66	93.20	93.73	94.27	94.81	95.34	95.83	96.37	96.91	97.40	97.94	98.43	98.92	99.46	99.95	100.4	100.9
21	93.31	93.86	94.46	94.96	95.51	96.06	96.61	97.16	97.71	98.21	98.76	99.31	99.82	100.4	100.9	101.4	101.9	102.4	102.9	103.4
22	95.49	96.05	96.66	97.18	97.74	98.30	98.87	99.43	99.99	100.5	101.1	101.6	102.1	102.7	103.2	103.7	104.3	104.8	105.3	105.9
23	97.65	98.22	98.85	99.37	99.95	100.5	101.1	101.7	102.3	102.8	103.4	103.9	104.5	105.0	105.6	106.1	106.7	107.2	107.7	108.2
24	99.74	100.3	101.0	101.5	102.1	102.7	103.3	103.9	104.4	105.0	105.6	106.2	106.7	107.3	107.8	108.4	109.0	109.5	110.0	110.6
25	101.8	102.4	103.1	103.6	104.2	104.8	105.4	106.0	106.6	107.2	107.8	108.4	108.9	109.5	110.1	110.6	111.2	111.8	112.3	112.9
26	103.8	104.4	105.1	105.7	106.3	106.9	107.5	108.1	108.7	109.3	109.9	110.5	111.1	111.7	112.2	112.8	113.4	114.0	114.5	115.1
27	105.8	106.4	107.1	107.7	108.3	108.9	109.5	110.2	110.8	111.4	112.0	112.6	113.2	113.8	114.4	114.9	115.6	116.1	116.7	117.3
28	107.7	108.4	109.1	109.7	110.3	110.9	111.6	112.2	112.8	113.4	114.0	114.7	115.3	115.9	116.5	117.1	117.7	118.3	118.9	119.4
29	109.6	110.3	111.0	111.6	112.2	112.9	113.5	114.2	114.8	115.4	116.0	116.7	117.3	117.9	118.5	119.1	119.8	120.4	120.9	121.5
30	111.5	112.2	112.9	113.5	114.1	114.8	115.5	116.1	116.8	117.4	118.0	118.7	119.3	119.9	120.5	121.2	121.8	122.4	123.0	123.6
31	113.4	114.0	114.8	115.4	116.0	116.7	117.4	118.0	118.7	119.3	120.0	120.7	121.3	121.9	122.6	123.2	123.8	124.4	125.1	125.7
32	115.2	115.9	116.6	117.2	117.9	118.6	119.2	119.9	120.6	121.2	121.9	122.6	123.2	123.9	124.5	125.1	125.8	126.4	127.1	127.7
33	117.0	117.7	118.4	119.0	119.7	120.4	121.1	121.8	122.5	123.1	123.8	124.5	125.1	125.8	126.4	127.1	127.8	128.4	129.0	129.7
34	118.7	119.4	120.2	120.8	121.5	122.2	122.9	123.6	124.3	125.0	125.7	126.4	127.0	127.7	128.3	129.0	129.7	130.3	131.0	131.6
35	120.4	121.2	121.9	122.6	123.3	124.0	124.7	125.4	126.1	126.8	127.5	128.2	128.9	129.6	130.2	130.9	131.6	132.2	132.9	133.5
36	122.2	122.9	123.7	124.3	125.0	125.8	126.5	127.2	127.9	128.6	129.3	130.0	130.7	131.4	132.1	132.7	133.4	134.1	134.8	135.4
37	123.8	124.6	125.4	126.0	126.8	127.5	128.2	129.0	129.7	130.4	131.1	131.8	132.5	133.2	133.9	134.6	135.3	136.0	136.6	137.3
38	125.5	126.2	127.0	127.7	128.5	129.2	129.9	130.7	131.4	132.1	132.8	133.6	134.3	135.0	135.7	136.3	137.1	137.8	138.4	139.1
39	127.1	127.9	128.7	129.4	130.1	130.9	131.6	132.4	133.1	133.8	134.6	135.3	136.0	136.8	137.5	138.1	138.9	139.6	140.3	140.9
40	128.8	129.5	130.4	131.1	131.8	132.6	133.3	134.1	134.8	135.5	136.3	137.1	137.8	138.5	139.2	139.9	140.7	141.4	142.1	142.8
41	130.4	131.1	132.0	132.7	133.4	134.2	135.0	135.7	136.5	137.2	138.0	138.8	139.5	140.2	140.9	141.6	142.4	143.1	143.8	144.5
42	132.0	132.7	133.6	134.3	135.1	135.8	136.6	137.4	138.2	138.9	139.7	140.4	141.2	141.9	142.6	143.4	144.1	144.9	145.6	146.3
43	133.5	134.3	135.1	135.9	136.6	137.4	138.2	139.0	139.8	140.5	141.3	142.1	142.8	143.6	144.3	145.0	145.8	146.5	147.3	148.0
44	135.0	135.8	136.7	137.4	138.2	139.0	139.8	140.6	141.4	142.1	142.9	143.7	144.5	145.3	146.0	146.7	147.5	148.2	149.0	149.7
45	136.6	137.4	138.3	139.0	139.8	140.6	141.4	142.2	143.0	143.8	144.6	145.4	146.1	146.9	147.6	148.4	149.2	149.9	150.7	151.4
46	138.1	138.9	139.8	140.5	141.3	142.2	143.0	143.8	144.6	145.3	146.2	147.0	147.7	148.5	149.3	150.0	150.8	151.6	152.3	153.1
47	139.6	140.4	141.3	142.1	142.9	143.7	144.5	145.3	146.2	146.9	147.7	148.6	149.3	150.1	150.9	151.7	152.5	153.2	154.0	154.7
48	141.1	141.9	142.8	143.5	144.4	145.2	146.0	146.9	147.7	148.5	149.3	150.1	150.9	151.7	152.5	153.2	154.1	154.8	155.6	156.4
49	142.5	143.4	144.3	145.0	145.9	146.7	147.6	148.4	149.2	150.0	150.9	151.7	152.5	153.3	154.1	154.8	155.7	156.5	157.2	158.0
50	144.0	144.8	145.7	146.5	147.4	148.2	149.1	149.9	150.8	151.5	152.4	153.2	154.0	154.9	155.7	156.4	157.3	158.0	158.8	159.6
51	145.4	146.2	147.2	148.0	148.8	149.7	150.5	151.4	152.2	153.0	153.9	154.7	155.5	156.4	157.2	158.0	158.8	159.6	160.4	161.2
52	146.8	147.7	148.6	149.4	150.3	151.1	152.0	152.9	153.7	154.5	155.4	156.3	157.1	157.9	158.7	159.5	160.4	161.2	162.0	162.8
53	148.2	149.1	150.0	150.8	151.7	152.6	153.5	154.3	155.2	156.0	156.9	157.8	158.6	159.4	160.2	161.0	161.9	162.7	163.5	164.3
54	149.6	150.5	151.4	152.3	153.1	154.0	154.9	155.8	156.7	157.5	158.3	159.2	160.0	160.9	161.7	162.5	163.4	164.2	165.0	165.8
55	151.0	151.9	152.8	153.7	154.5	155.4	156.3	157.2	158.1	158.9	159.8	160.7	161.5	162.4	163.2	164.0	164.9	165.7	166.6	167.4
56	152.4	153.3	154.2	155.0	155.9	156.8	157.7	158.6	159.5	160.4	161.3	162.2	163.0	163.9	164.7	165.5	166.4	167.2	168.1	168.9
57	153.7	154.6	155.6	156.4	157.3	158.2	159.2	160.1	161.0	161.8	162.7	163.6	164.4	165.3	166.2	167.0	167.9	168.7	169.6	170.4
58	155.1	156.0	157.0	157.8	158.7	159.6	160.5	161.5	162.4	163.2	164.1	165.0	165.9	166.8	167.6	168.5	169.4	170.2	171.1	171.9
59	156.4	157.3	158.3	159.2	160.1	161.0	161.9	162.8	163.8	164.6	165.5	166.4	167.3	168.2	169.1	169.9	170.8	171.7	172.5	173.4
60	157.7	158.6	159.6	160.5	161.4	162.4	163.3	164.2	165.1	166.0	166.9	167.9	168.7	169.6	170.5	171.3	172.3	173.1	174.0	174.8
61	159.0	159.9	161.0	161.8	162.8	163.7	164.6	165.6	166.5	167.4	168.3	169.2	170.1	171.0	171.9	172.8	173.7	174.6	175.4	176.3
62	160.3	161.3	162.3	163.1	164.1	165.0	166.0	166.9	167.9	168.7	169.7	170.6	171.5	172.4	173.3	174.2	175.1	176.0	176.9	177.7
63	161.6	162.5	163.6	164.5	165.4	166.4	167.3	168.3	169.2	170.1	171.0	172.0	172.9	173.8	174.7	175.6	176.5	177.4	178.3	179.1
64	162.9	163.8	164.9	165.8	166.7	167.7	168.6	169.6	170.6	171.4	172.4	173.4	174.2	175.2	176.1	177.0	177.9	178.8	179.7	180.6
65	164.1	165.1	166.2	167.0	168.0	169.0	169.9	170.9	171.9	172.8	173.7	174.7	175.6	176.6	177.4	178.3	179.3	180.2	181.1	182.0
66	165.4	166.4	167.4	168.3	169.3	170.3	171.3	172.2	173.2	174.1	175.1	176.0	176.9	177.9	178.8	179.7	180.7	181.6	182.5	183.4
67	166.6	167.6	168.7	169.6	170.6	171.6	172.5	173.5	174.5	175.4	176.4	177.4	178.3	179.3	180.2	181.1	182.0	182.9	183.8	184.7
68	167.9	168.9	170.0	170.9	171.8	172.8	173.8	174.8	175.8	176.7	177.7	178.7	179.6	180.6	181.5	182.4	183.4	184.3	185.2	186.1
69	169.1	170.1	171.2	172.1	173.1	174.1	175.1	176.1	177.1	178.0	179.0	180.0	180.9	181.9	182.8	183.8	184.7	185.7	186.6	187.5
70	170.4	171.4	172.4	173.4	174.4	175.4	176.4	177.4	178.4	179.3	180.3	181.3	182.2	183.2	184.2	185.1	186.1	187.0	187.9	188.8
71	171.6	172.6	173.7	174.6	175.6	176.6	177.6	178.6	179.6	180.6	181.6	182.6	183.5	184.5	185.5	186.4	187.4	188.3	189.2	190.2
72	172.8	173.8	174.9	175.8	176.8	177.8	178.9	179.9	180.9	181.8	182.9	183.9	184.8	185.8	186.8	187.7	188.7	189.6	190.6	191.5
73	174.0	175.0	176.1	177.0	178.1	179.1	180.1	181.1	182.2	183.1	184.1	185.1	186.1	187.1	188.1	189.0	190.0	191.0	191.9	192.8
74	175.1	176.2	177.3	178.2	179.3	180.3	181.3	182.4	183.4	184.3	185.4	186.4	187.4	188.4	189.3	190.3	191.3	192.3	193.2	194.1
75	176.3	177.4	178.5	179.4	180.5	181.5	182.6	183.6	184.6	185.6	186.6	187.7	188.6	189.7	190.6	191.6	192.6	193.6	194.5	195.5
76	177.5	178.5	179.7	180.6	181.7	182.7	183.8	184.8	185.9	186.8	187.9	188.9	190.0	190.9	191.9	192.8	193.9	194.8	195.8	196.8
77	178.7	179.7	180.9	181.8	182.9	183.9	185.0	186.0	187.1	188.0	189.1	190.2	191.1	192.2	193.1	194.1	195.1	196.1	197.1	198.1
78	179.8	180.9	182.0	183.0	184.1	185.1	186.2	187.2	188.3	189.3	190.3	191.4	192.4	193.4	194.4	195.4	196.4	197.4	198.4	199.3
79	181.0	182.0	183.2	184.2	185.2	186.3	187.4	188.4	189.5	190.5	191.5	192.6	193.6	194.6	195.6	196.6	197.7	198.6	199.6	200.6
80	182.1	183.2	184.3	185.3	186.4	187.5	188.5	189.6	190.7	191.7	192.7	193.8	194.8	195.9	196.9	197.8	198.9	199.9	200.9	201.9
82	184.4	185.4	186.6	187.6	188.7	189.8	190.9	192.0	193.1	194.0	195.1	196.2	197.2	198.3	199.3	200.3	201.4	202.4	203.4	204.4
84	186.6	187.7	188.9	189.9	191.0	192.1	193.2	194.3	195.4	196.4	197.5	198.6	199.6	200.7	201.7	202.7	203.8	204.8	205.8	206.9
86	188.8	189.9	191.1	192.2	193.3	194.4	195.5	196.6	197.7	198.7	199.9	201.0	202.0	203.1	204.1	205.1	206.3	207.3	208.3	209.3
88	191.0	192.1	193.3	194.4	195.5	196.6	197.8	198.9	200.0	201.0	202.2	203.3	204.3	205.4	206.5	207.5	208.6	209.7	210.7	211.7
90	193.2	194.3	195.5	196.6	197.7	198.8	200.0	201.1	202.3	203.3	204.4	205.6	206.6	207.8	208.8	209.9	211.0	212.0	213.1	214.1
92	195.3	196.4	197.7	198.7	199.9	201.0	202.2	203.4	204.5	205.6	206.7	207.9	208.9	210.1	211.1	212.2	213.3	214.4	215.4	216.5
94	197.4	198.6	199.8	200.9	202.0	203.2	204.4	205.5	206.7	207.8	208.9	210.1	211.2	212.3	213.4	214.5	215.6	216.7	217.7	218.8
96	199.5	200.7	201.9	203.0	204.2	205.4	206.5	207.7	208.9	210.0	211.1	212.3	213.4	214.6	215.7	216.7	217.9	219.0	220.1	221.1
98	201.5	202.7	204.0	205.1	206.3	207.5	208.7	209.9	211.0	212.1	213.3	214.5	215.1	216.8	217.9	219.0	220.2	221.2	222.3	223.4
100	203.6	204.8	206.1	207.2	208.4	209.6	210.8	212.0	213.2	214.3	215.5	216.7	217.8	219.0	220.1	221.2	222.4	223.5	224.6	225.7

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in inches of water and lb. per sq. in., abs., respectively.

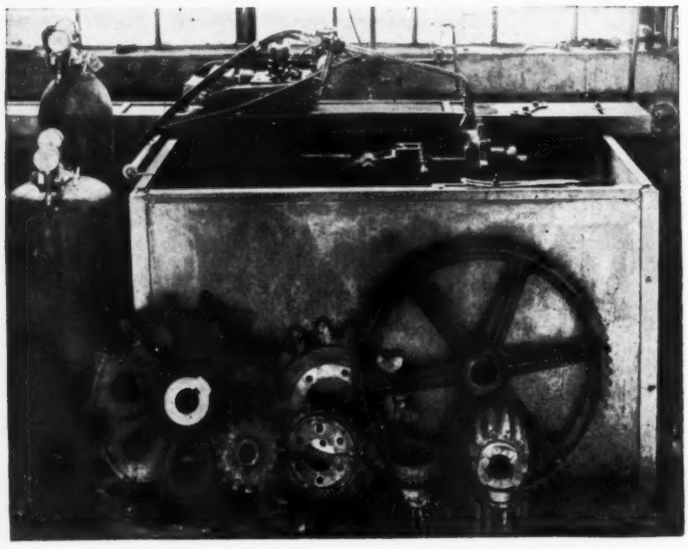
Absolute pressures are based on atmospheric pressure of 14.4 lb. per sq. in.

Table has been condensed to serve field men in approximating meter readings; intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

AIRCO FLAME-HARDENING

. . . makes wearing parts last longer — equipment more serviceable

Close-up of gear tooth being flame-hardened, showing water quench.



A group of flame-hardened parts used in Buckeye equipment.

Vital wearing parts—spur gear teeth, bevel pinions, sprockets, dipper teeth—last many times their normal life span when Airco Flame-Hardened. That's why the Buckeye Traction Ditcher Company, Findlay, Ohio, utilizes this quick, inexpensive Airco process to safeguard wearing parts on their construction equipment—and assure maximum, trouble-free service for the buyer. This process has enabled Buckeye to maintain a stock of hardened parts which can be machined to proper hub bore when needed. » » » This economical Airco method of case hardening steel surfaces is accomplished without materially affecting the physical properties of the core. More ductile metal, highly resistant to shock and strain, without danger of warpage, is assured when parts are Airco Flame-Hardened. » » » The facilities of Airco's Applied Engineering Department are available to help Airco customers solve problems involving surface wear. Write for full details.

AIR REDUCTION

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MAGNOLIA-AIRCO GAS PRODUCTS CO. HOUSTON, BEAUMONT, WICHITA FALLS, FORT WORTH, DALLAS, EL PASO, SAN ANTONIO

CRUTCHER-ROLFS-CUMMINGS HOUSTON

AIRCO DISTRICT OFFICES IN PRINCIPAL CITIES

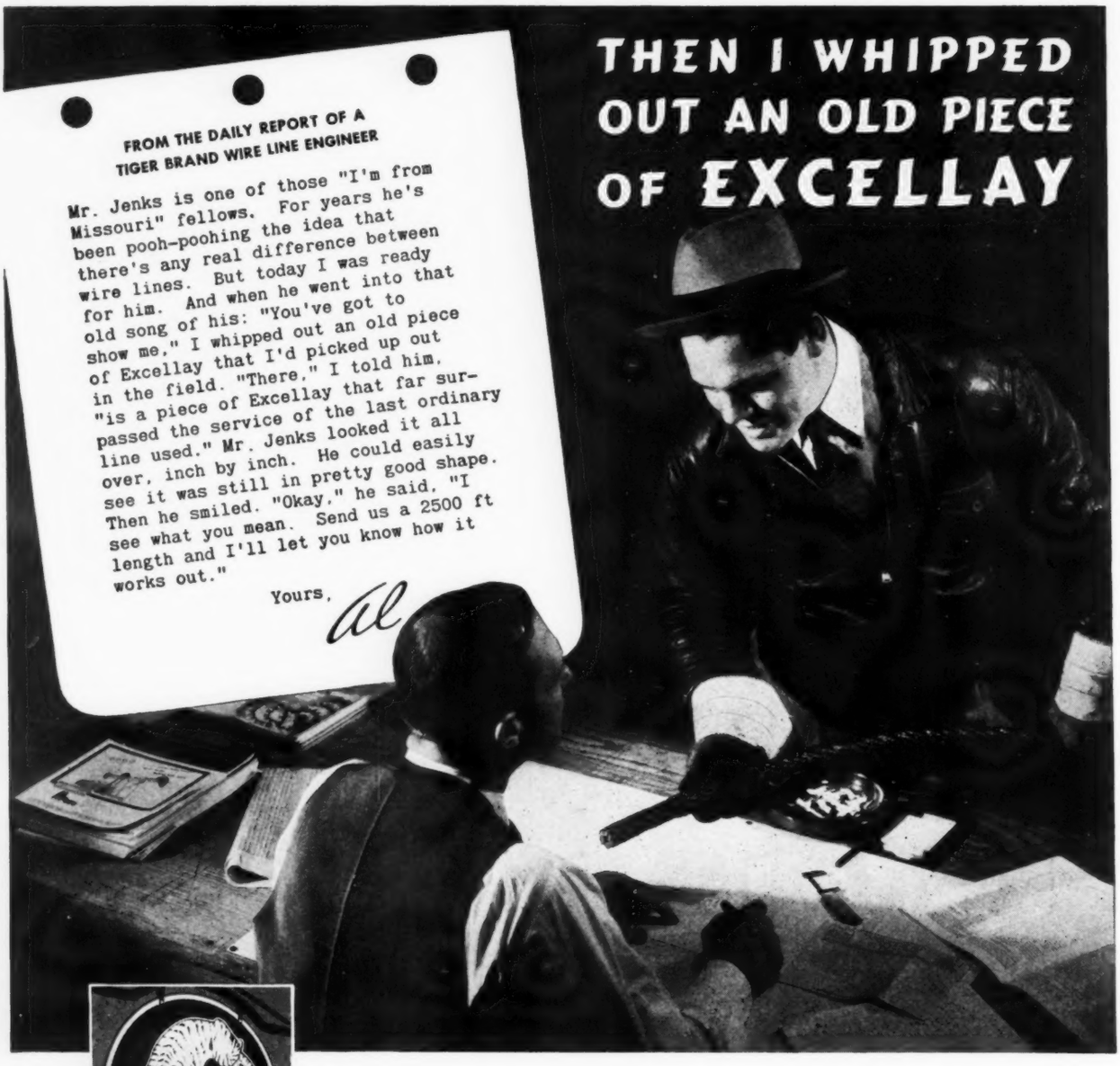
Represented in Canada by RAILWAY & ENGINEERING SPECIALTIES, LTD., and CANADIAN LIQUID AIR COMPANY, LTD., Toronto, Montreal, Winnipeg

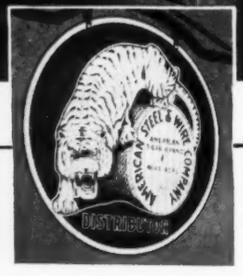
AIRCO *Anything and Everything for* GAS WELDING or CUTTING and ARC WELDING WILSON

VELOCITY OF FLUID THROUGH ANNULUS BETWEEN 2⅞-IN. DRILL PIPE AND OPEN HOLE, FT. PER SEC.

Pumprate		Diameter of open hole, in. Area of annulus, sq. in.											
Gal. per min.	Bbl. per hr.	8⅜	8⅝	9⅝	9⅞	10⅝	11	12¼	13¾	14¾	15½	17	17½
		48.60	**51.94**	**66.27**	**70.10**	**82.17**	**88.54**	**111.4**	**142.0**	**164.4**	**182.2**	**220.5**	**234.0**
150	214												
160	229	1.06											
170	243	1.12	1.05										
180	257	1.19	1.11										
190	271	1.25	1.17										
200	286	1.32	1.24										
210	300	1.39	1.30	1.02									
220	314	1.45	1.36	1.07	1.01								
230	329	1.52	1.42	1.11	1.05								
240	343	1.58	1.48	1.16	1.10								
250	357	1.65	1.54	1.21	1.14								
260	371	1.72	1.61	1.26	1.19	1.02							
270	386	1.78	1.67	1.31	1.24	1.05							
280	400	1.85	1.73	1.36	1.28	1.09	1.01						
290	414	1.91	1.78	1.40	1.33	1.13	1.05						
300	429	1.98	1.85	1.45	1.37	1.17	1.09						
310	443	2.05	1.92	1.50	1.42	1.21	1.12						
320	457	2.11	1.98	1.55	1.76	1.25	1.16						
330	471	2.18	2.04	1.60	1.51	1.29	1.20						
340	486	2.24	2.10	1.65	1.56	1.33	1.23						
350	500	2.31	2.16	1.69	1.60	1.37	1.27	1.01					
360	514	2.38	2.22	1.74	1.65	1.41	1.30	1.04					
370	529	2.44	2.29	1.79	1.69	1.44	1.34	1.07					
380	543	2.51	2.35	1.84	1.74	1.48	1.38	1.09					
390	557	2.57	2.41	1.89	1.79	1.52	1.41	1.12					
400	571	2.64	2.47	1.94	1.83	1.56	1.45	1.15					
410	586	2.71	2.53	1.98	1.88	1.60	1.49	1.18					
420	600	2.77	2.59	2.03	1.92	1.64	1.52	1.21					
430	614	2.84	2.66	2.08	1.97	1.68	1.56	1.24					
440	629	2.90	2.72	2.13	2.01	1.72	1.59	1.27					
450	643	2.97	2.78	2.06	1.76	1.63	1.30	1.02					
460	657	3.04	2.84	2.23	2.11	1.80	1.67	1.33	1.04				
470	671	3.10	2.90	2.28	2.15	1.83	1.70	1.35	1.06				
480	686	3.17	2.97	2.32	2.20	1.87	1.74	1.38	1.08				
490	700	3.23	3.03	2.37	2.24	1.91	1.78	1.41	1.11				
500	714	3.30	3.09	2.42	2.29	1.95	1.81	1.44	1.13				
510	729	3.37	3.15	2.47	2.33	1.99	1.85	1.47	1.15				
520	743	3.43	3.21	2.52	2.38	2.03	1.88	1.50	1.17	1.02			
530	757	3.50	3.27	2.57	2.43	2.07	1.92	1.53	1.20	1.03			
540	771	3.57	3.34	2.61	2.47	2.11	1.96	1.56	1.22	1.05			
550	786	3.63	3.40	2.66	2.52	2.15	1.99	1.58	1.24	1.07			
560	800	3.70	3.46	2.71	2.56	2.19	2.03	1.61	1.27	1.09			
570	814	3.76	3.52	2.76	2.61	2.23	2.07	1.64	1.29	1.11	1.00		
580	829	3.83	3.58	2.81	2.65	2.26	2.10	1.67	1.31	1.13	1.02		
590	843	3.90	3.65	2.86	2.70	2.30	2.14	1.70	1.33	1.15	1.04		
600	857	3.96	3.71	2.90	2.75	2.34	2.17	1.73	1.36	1.17	1.06		
650	929	4.29	4.02	3.15	2.98	2.54	2.21	1.87	1.47	1.27	1.14		
700	1000	4.62	4.32	3.39	3.20	2.73	2.25	2.02	1.58	1.37	1.23	1.02	
750	1071	4.95	4.63	3.63	3.43	2.93	2.28	2.16	1.69	1.46	1.32	1.09	1.03
800	1143	5.28	4.94	3.87	3.66	3.12	2.32	2.30	1.81	1.56	1.41	1.16	1.10
850	1214	5.61	5.25	4.11	3.89	3.32	2.36	2.45	1.92	1.66	1.50	1.24	1.17
900	1286	5.94	5.56	4.36	4.12	3.51	2.39	2.59	2.03	1.76	1.58	1.31	1.23
950	1357	6.27	5.87	4.60	4.35	3.71	2.43	2.74	2.15	1.85	1.67	1.38	1.30
1000	1429	6.60	6.18	4.84	4.58	3.90	2.46	2.88	2.26	1.95	1.76	1.46	1.37
1050	1500	6.93	6.49	5.08	4.81	4.10	2.50	3.03	2.37	2.05	1.85	1.53	1.44
1100	1571	7.26	6.80	5.33	5.03	4.29	2.54	3.17	2.48	2.15	1.94	1.60	1.51
1200	1714	7.92	7.41	5.81	5.49	4.68	2.57	3.46	2.71	2.34	2.11	1.75	1.65
1300	1857	8.58	8.03	6.29	5.95	5.08	2.61	3.75	2.94	2.54	2.29	1.89	1.78
1400	2000	9.24	8.65	6.78	6.41	5.47	2.65	4.03	3.16	2.73	2.47	2.04	1.92
1500	2143	9.90	9.27	7.26	6.87	5.86	2.68	4.32	3.39	2.93	2.64	2.18	2.06

THEN I WHIPPED OUT AN OLD PIECE OF EXCELLAY


FROM THE DAILY REPORT OF A
TIGER BRAND WIRE LINE ENGINEER
Mr. Jenks is one of those "I'm from Missouri" fellows. For years he's been pooh-poohing the idea that there's any real difference between wire lines. But today I was ready for him. And when he went into that old song of his: "You've got to show me," I whipped out an old piece of Excellay that I'd picked up out in the field. "There," I told him, "is a piece of Excellay that far surpassed the service of the last ordinary line used." Mr. Jenks looked it all over, inch by inch. He could easily see it was still in pretty good shape. Then he smiled. "Okay," he said, "I see what you mean. Send us a 2500 ft length and I'll let you know how it works out."
Yours,
al



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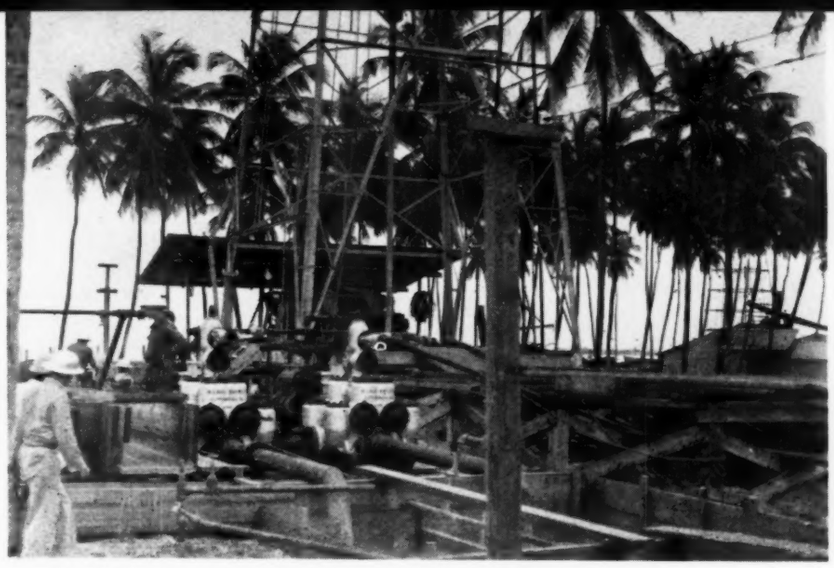


P 425.218.4

Slush pumps on a drilling operation in Maceio, Brazil, area

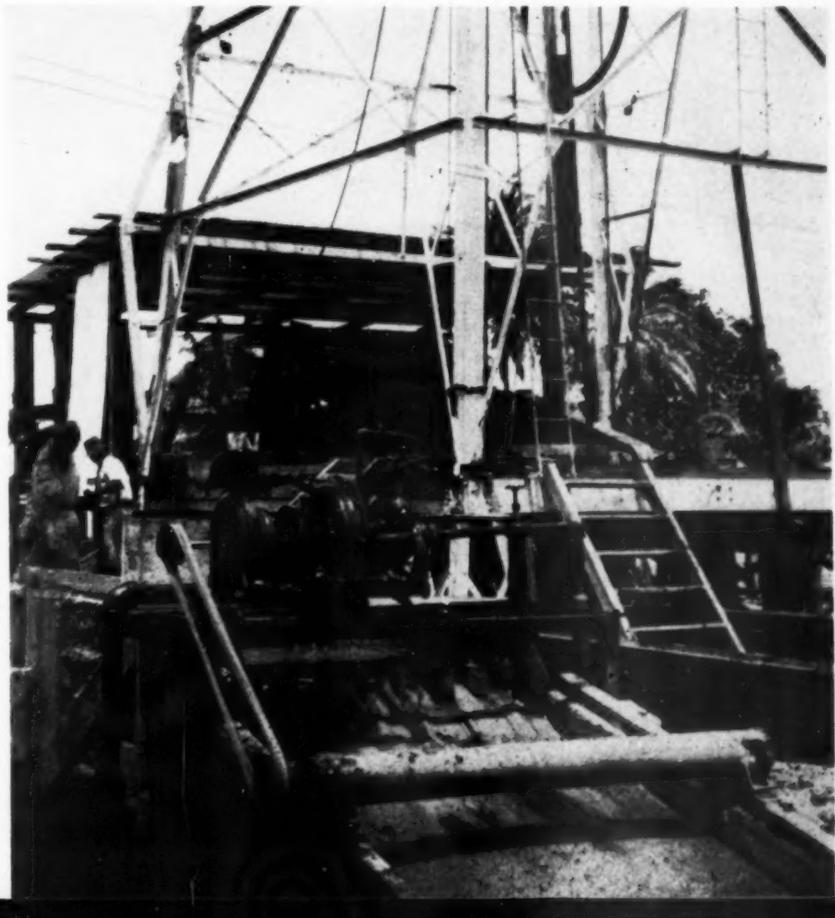
Knowledge of Mud Characteristics and Control Augments Drilling Efficiency

More definitely the province of the chemical engineer, mud control now embraces use of many chemical ingredients to obtain the proper mixtures

By WALLACE A. SAWDON
Pacific Coast and Foreign Editor

WHETHER the most desirable clay is readily available or not, the best drilling fluid possible under existing conditions should be supplied to rotary drilling operations. Formations penetrated may add to or detract from the quality of the mud being used and the control of the properties of the circulating fluid as the well progresses often requires greater consideration than the condition of the initial fluid as drilling begins. Drilling requirements themselves may change considerably as greater depths are reached and the characteristics of the mud fluid, especially the weight, may have to be altered from time to time. Conditioning of the mud fluid, with consistent testing to obtain data for its control, is therefore an important factor in the successful and economic completion of a well and deserves the increased attention now being given to mud control in operations throughout the world.

Mud weight requirements will be governed, of course, by the formation pressures encountered. The most extreme pressure conditions are probably in the Punjab in India but the great pressures in such fields as Khaur in that area are overcome by the use of pressure drilling. In other high-pressure areas such as Trinidad where pressures considerably in excess of the hydrostatic head of water are frequently encountered, the drilling is done with mud control and mud weights of 130 lb. per cu. ft. are not uncommon. There is a possibility, however, that the weight of the mud being used in such operations could be reduced to some extent if proper and consistent attention were paid to the other properties of the fluid. A reduction in weight would aid considerably in the cementing procedure and as surface control equipment is used on these high-pressure wells, any emergency can be met. A continued study of this problem may result in facilitated drilling practice and even in better production from some of the productive zones.



Vibrating screen on a foreign drilling well

Although of great importance in drilling through high-pressure formations, weight is not the only mud characteristic to be considered and even the effectiveness of the weight itself may be influenced by other properties of the drilling fluid. The primary function of the fluid is to remove the cuttings from the well and to do this it must hold the cuttings in suspension and prevent their settling when circulation is stopped. Yet fine, inert matter such as sand that will pass through a vibrating screen must be settled-out. The importance of wall-building qualities that cause a thin filter cake to form on porus formations and prevent loss of water has become generally recognized, as has also the fact that wall-building qualities are frequently indicative of the general condition of the fluid. All these qualities, except weight but including lubrication, are dependent on the colloidal content of the mud and its thixotropic properties. The ideal mud cannot, of course, be realized for every well or even for the entire drilling of many wells. Certain qualities of the drilling fluid must necessarily be of greater importance under some drilling conditions and others under different conditions.

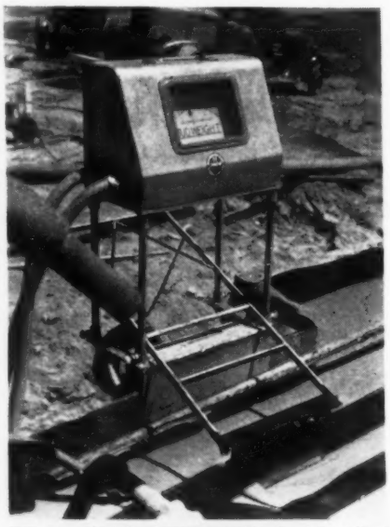
The important factor in mud control is in getting a mix that will have the best characteristics for the existing requirements, keeping it in proper condition and providing it with different qualities to meet any changing subsurface conditions as they are encountered during drilling. Data on which to base the control are obtained by frequent, periodic tests; the conditioning is done by physical, mechanical, or chemical means, or a combination of these. Beginning with tests on the basic clay from which the drilling fluid is to be compounded, the mixture can be made to provide to the greatest extent possible the necessary properties from the start. In many countries a good native base clay is not available and the use of admixtures may be of considerable importance.

The mud derived from the formations in the hole during drilling will often be the means of obtaining a satisfactory drilling fluid; at other times it may be detrimental to the mix. Although this formation mud may provide the necessary colloidal content lacking in the basic clay available it will not always supply the weight required and can never be relied upon without the addition of weight material when high pressure is encountered. In some fields in the United States the basic mud fluid does not have to be changed during the entire drilling of the well; but its weight, colloidal content, or viscosity may have to be altered considerably before the bottom is reached.

Colloidal Properties

All characteristics of a drilling mud are more or less related to the colloidal content of the fluid. Even the heavy, inert material introduced to provide weight depends on colloids to hold it in suspension; and the gas entrapped in the mud, which reduces its weight, is held by colloidal action. Conditioning of the drilling fluid is thus obtained by the increase or reduction of colloidal concentration, by deflocculation of colloids, or by control of colloidal action. It is the presence of colloids in the drilling mud that maintains the cuttings in suspension and provides thixotropy. This property causes the fluid to gel when not in motion and to return to a liquid state when agitated. The transformation from gel to liquid and from liquid to gel can be repeated so long as thixotropy maintains.

This new electrical device placed in the mud stream gives a continuous indication of the weight of the mud fluid. The indicator may be set at the mud ditch (top), or at the driller's position (below), some operations using it at both places



Thixotropy is measured by the difference in gel strength at the cessation of agitation and at the end of a period of quiescence. The shear or gel strength is now being measured in some American operations by a shearometer in lb. per 100 sq. ft. In other cases the gel strength is determined by means of a Stormer viscosimeter. Although an increase in viscosity usually accompanies an increase in thixotropy, the viscosity does not specifically indicate the thixotropic conditions. A high viscosity may result from a high concentration of inert matter and not from the colloidal content of the mud fluid.

Viscosity is an important factor and should be given consistent attention in mud control; but in cases where there is doubt as to its cause other tests should be made. Treatment of a mud to reduce viscosity by reduction of colloidal concentration may result in a worse fluid if the viscosity has been increased by inert material when the mud itself is deficient in colloids. Viscosity tests are usually made with the Marsh funnel but the Stormer viscosimeter is coming into greater use for viscosity determination.

On the colloidal concentration also depends the thickness of mud sheath and rate of water loss. The filter cake deposited on the wall of the hole is produced by the minute colloidal solids collecting on the face of a porous formation when the water has been pressed from the fluid. A highly colloidal mud will quickly deposit an effective cake that will reduce further passage of water through it to a negligible amount. Inasmuch as the thickness of the filter cake depends on how rapidly the solids build the nearly impervious sheath on the wall of the hole, a good mud will form a water seal on a pervious formation before the cake becomes very thick and will thus reduce water loss to a minimum in the shortest possible time.

A mud may form a thick cake on the wall of the hole and yet not prevent water loss because of high content of inert solids and deficiency in colloids. The cake thickness is increased either by the deficiency of colloids, by the presence of non-colloidal material, or by a combination of both. This may be caused during drilling by picking up sand or other inert material from the formations; and as the

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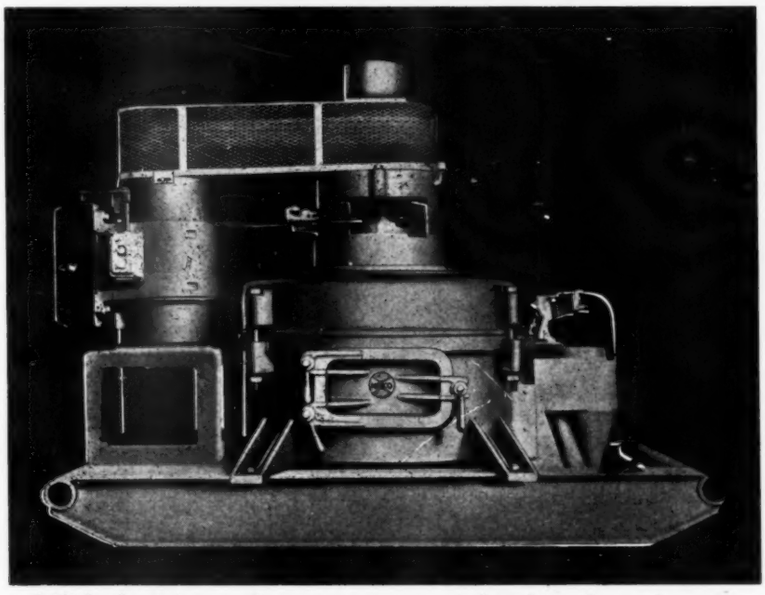
THE CONDITION & COST OF YOUR



MUD

★ **RECOVER Weighted Mud**
★ **MAINTAIN Mud Weight**
★ **CONTROL Mud Viscosity**
★ **SAVE Weighting Material**

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With the Merco Concentrator, weighted mud can be constantly controlled and maintained at the desired predetermined consistency and weight, without needless loss of costly weighting material. Valuable weighted mud can likewise be economically recovered for re-use from waste sumps after drilling operations have been terminated. This is accomplished by decanting a major portion of the mud and concentrating the weighting material in the remainder. Any oil, gas or salt water is thereby eliminated and discarded. By this cost-saving method—weighting material can be conserved and used over and over again. Actual operating figures show a 90% recovery of weighting material concentrated at 120-130 lbs./cu. ft.

In addition to maintaining the desired mud weight and viscosity, the Merco Concentrator can be employed to ***increase*** mud weight without the wasteful addition of weighting material.

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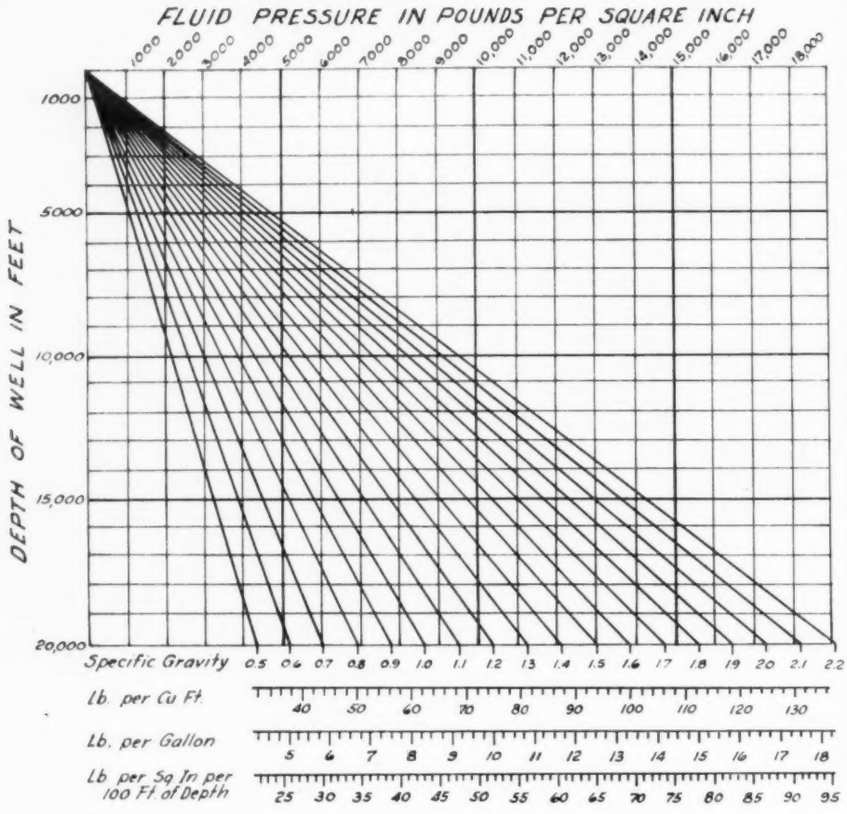


Fig. 1. Pressure exerted by a column of mud of any given weight for depths to 20,000 ft.

wall-building quality of the mud is one of the important properties of a satisfactory drilling fluid, tests for it should be made periodically.

The practice extensively followed in many fields is to use a filter press designed for field service. A pressure of 100 lb. per sq. in. is applied to a sample of 600 cc. of the mud fluid. At this pressure the cake thickness is determined to the nearest 1/32 in. and the water loss measured in cc. for a 30-min. run. The temperature of the mud before the test is made is used as the temperature of the run.

There is a relationship between the thixotropic and wall-building qualities of the mud but it is only by testing that actual effectiveness of each can be definitely known. Both are dependent on colloidal concentration and this concentration is likely to be changed during drilling. Some formations penetrated will rob the fluid of colloids and necessitate additions to keep the mud in proper condition. Other formations, such as those with bentonitic inclusions, will add colloids to the mud as it is being circulated and will make a reduction of colloids necessary. The colloidal content is usually increased by the addition of a prepared bentonite and is generally reduced by thinning the mud fluid.

High temperatures affect the mud fluid and tests for viscosity, gel strength, and wall-building properties should be made at the operating temperature. High temperatures increase water loss with any mud but, although the amount and rate of loss vary widely with different muds, those with strong thixotropic qualities form a thinner cake and allow a considerably lower water loss than muds with even moderately strong thixotropy. The viscosity nearly always decreases with an increase of temperature to a certain point but then starts to increase.

Some pressure is necessary to force the water from the mud and into the formation in order to form the filter cake. There is a difference in the wall-building qualities of different muds under increasing pressure and the most effective from a wall-building standpoint is probably a fluid made entirely of prepared bentonite and water. Such a fluid has been found to show no appreciable change in cake thickness or water loss after reaching a pressure of approximately 100 lb. per sq. in. Although the effect of pressure will probably continue in varying degrees with nearly all muds under pressure higher than 100 lb., this pressure is generally used in field tests and will give results that are indicative of the wall-building qualities of the mud.

The thixotropic, gel strength, viscosity, gas-absorption, and corrosive properties are closely related to the hydrogen-ion concentration or pH value of the mud fluid and tests for this property will provide the means of detecting changes in the alkalinity or acidity of the fluid. These tests are made either by the colorimetric or electrometric method; and although the equipment for the tests is used principally in the field laboratary, it may be carried from well to well. A mud with low pH value is on the acid side and may have a corrosive effect on metal; one with high pH may be flocculated. That which is flocculated is often treated with chemicals to bring it back to condition.

Chemical Treatment

Chemical treatment of mud fluid is used to keep the colloids functioning. It controls colloidal action in the fluid and makes it more effective after the colloids have become flocculated. Chemical treatment does not increase or decrease the colloidal content of the mud; a mud deficient in colloids needs their addition and one too highly colloidal must be thinned to reduce colloidal concentration whether chemical treatment is used or not.

A great variety of chemicals is now being used as deflocculants. Of these, two of the complex phosphates (tetrasodium pyrophosphate and sodium tetra-phosphate) have come into rather extensive use. The pyrophosphate is highly alkaline and is more stable in hot muds than other complex phosphates. This chemical is used to deflocculate the mud and allows the hole to make fluid. By deflocculation the wall-building qualities are restored and the viscosity more easily controlled. The salts from the formation that cause flocculation are redispersed, and the inert solids picked-up during drilling are separated. If an excessive amount of chemical is used, however, the accumulative effect may be detrimental and high alkalinity may have to be reduced. The proportion for use will obviously vary under different conditions but the amount being used in some deep wells in California has been about 1 lb. per ft. of depth.

The tetra-phosphate is not as alkaline as the pyrophosphate and excessive use is not as harmful to the mud. It has been found effective with muds that have been previously treated and with mud that has been contaminated with salt.

Tannic acid—quebracho or chest-

Brick mud pit and ditch used in a drilling operation in Marau Basin, Brazil, by Solipema Petroleum, Ltd.

nut extract—has been extensively used as a thinner and to a limited extent as a deflocculating agent. It is generally applied as a sodium tannate made by neutralizing tannic acid with sodium hydroxide. Under certain conditions this chemical will not only thin the fluid but will help in stabilizing the colloidal content of the mud.

In applying chemical treatment to the drilling fluid as great an understanding as possible of colloidal chemistry should be gained in order to make the most intelligent use of the chemicals employed. An excess of chemical treatment not only increases the cost of operation but may result in damage to the mud stream. When drilling a formation that contributes fine, inert material to the circulating fluid, the use of chemicals will not prevent increase of the solid content. After treatment the mud may still remain at least partly flocculated; and although the fluid will not respond to further treatment it will still contain a high percentage of solids. The viscosity, caused by the high percentage of solids by volume and not by weight, becomes excessive and cannot be reduced except by dilution, which will necessitate addition of more weight material and sometimes more colloids.

Weight Control

The necessity for adding weight material to a drilling mud in order to overcome formation pressure is generally recognized. The weight material now widely used in American operations is prepared either from barytes or from an amorphous iron oxide. Either of these materials will meet any weight requirement in present-day drilling. In most cases they are mixed with sufficient colloidal material to insure their suspension in the circulating fluid; but when the mud in service has a high colloidal concentration the heavy inert solids alone are employed.

The pressure exerted by a column of mud of any given weight for depths to 20,000 ft. is shown by the curves in Fig. 1. Periodic tests will provide the means of knowing just what pressure is exerted by a static column of mud at any depth.

Testing for mud weight is done with the mud balance, hydrometer, or bucket-and-spring balance but the tendency is toward a more universal use of the mud balance. This device is usually graduated in "lb. per cu. ft." and in the A.P.I. density scale of "lb. per sq. in. per 100 ft. of depth"; but any desired scale can be used. An electrical instrument for continuous indication of mud weight has recently been introduced and by its use the weight of the fluid as it returns from the well can be read at any time.

Control of weight often requires a thinning of the mud fluid and this is usually done by the addition of water. Before thinning, tests should be made to make sure that the addition of water will not impair the other necessary properties of the mud and to determine whether other treatment such as the addition of colloidal material, removal of inert solids, or deflocculation is also necessary.

Gas-cut mud is a frequent cause of trouble and unfortunately occurs when a light mud is most dangerous. Vibrating screens, of which two are usually in service on deep wells, aid materially in releasing gas from the mud fluid as well as removing solid matter. When gas is in any quantity or is difficult to release, some form of degasser becomes advantageous. There are many types of degassers ranging from simple inclined baffle troughs with steps over which the gasified mud flows by gravity, to cylindrical tanks in which nozzles and baffles are used and in which a vacuum is sometimes carried.

Conclusion

Due to such a variety of conditions in the many fields throughout the world it is impossible to signify any "must" procedure for mud control. Complete testing and conditioning is not always possible but there are certain qualities of the mud that should be given greatest consideration after evaluating the importance of the different properties. Even the transportation of the basic clay, the mixing, and other factors are often serious problems in remote districts and indigenous labor is often used in a manner that seems strange to operators working under more favorable conditions.

In many cases the weight of the mud is of primary importance and its control imperative. In controlling the weight it must not be forgotten that other qualities in the mud may have a definite bearing on the weight to make it effective. Greater weight than really necessary is probably used in many instances when a mud of less weight could be employed to advantage provided the other properties of the mud were properly maintained.

The viscosity and wall-building properties should be controlled and although they are not always an exact measure of thixotropy they usually are indicative of the thixotropic condition of the fluid.

In addition to other tests mentioned, the sand content should sometimes be determined. The elutriation method with constant head is generally used and the sand content reported in percent by volume of approximately 200-mesh sand. To assist in the chemical treatment, especially in deep wells, the salt content of the fluid is sometimes determined. The tests for this purpose are made in the laboratory by titration with silver nitrate and the salt content is given in grains per gallon.

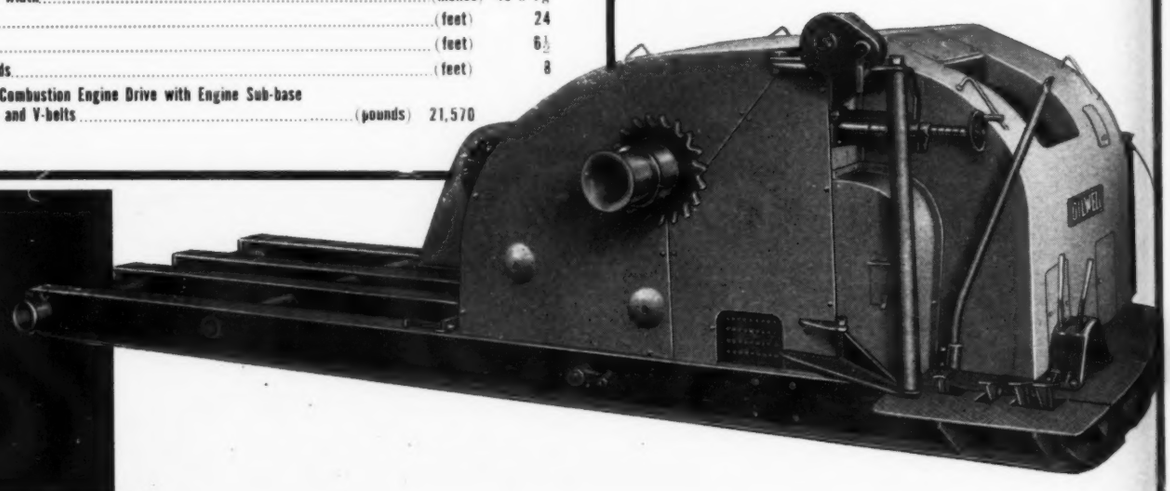
Field testing equipment for the periodic tests is now available in a form convenient for handling one or a number of wells. The addition of admixtures and chemical is an operating procedure and one that must be developed to meet the conditions encountered.

NEW "OILWELL"
FOR FASTER, SAFER,

"OILWELL" NO. 64 UNIVERSAL HOISTING UNIT

. . . a compact and portable four-speed hoist of unitized construction, providing ease of operation combined with utmost efficiency and dependability.

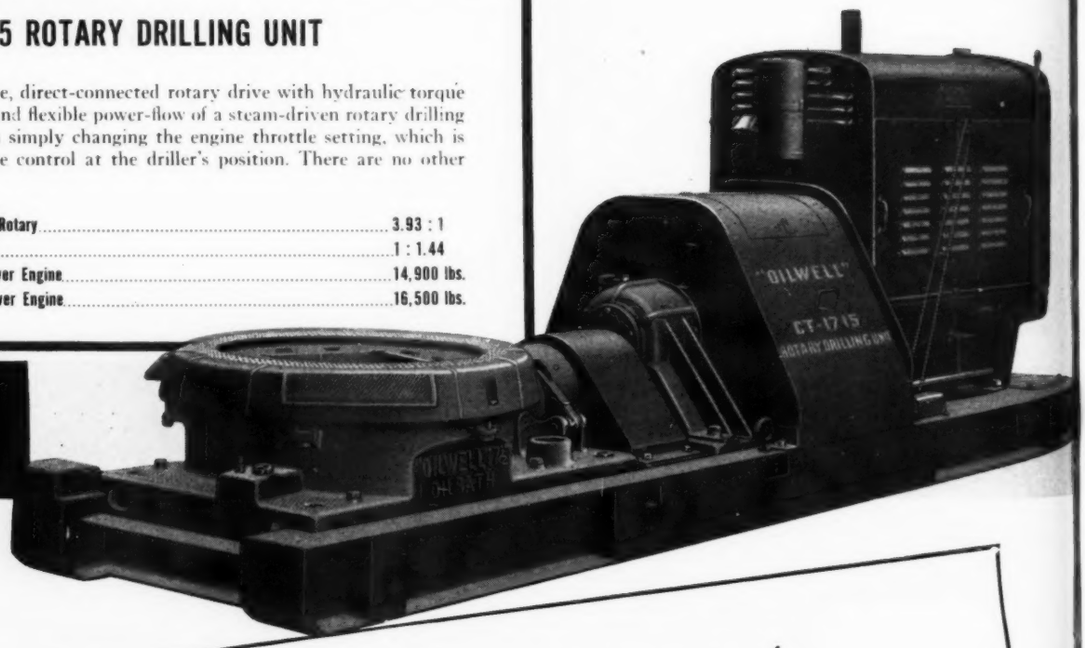
Recommended Max. Drilling Depth with 4½" Drill Pipe	(feet)	5,000
Drum: Spool Diameter	(inches)	16
Width between Flanges	(inches)	26½
Brake Rims, Diameter by Face Width	(inches)	46 x 7⅝
Length, Over-all	(feet)	24
Height, Over-all	(feet)	6½
Width, Over-all without Catheads	(feet)	8
Weight, Complete for Internal-Combustion Engine Drive with Engine Sub-base but less Engine and V-belts	(pounds)	21,570



"OILWELL" NO. CT-1715 ROTARY DRILLING UNIT

. . . an internal-combustion engine, direct-connected rotary drive with hydraulic torque converter, providing the smooth and flexible power-flow of a steam-driven rotary drilling unit. The drive responds through simply changing the engine throttle setting, which is regulated by a convenient remote control at the driller's position. There are no other controls and no clutches.

Speed Ratios:	"Oilwell" 17½-inch Oilbath Rotary	3.93 : 1
	Gear Box (Speed Increaser)	1 : 1.44
Weight:	Complete with 138 horsepower Engine	14,900 lbs.
	Complete with 193 horsepower Engine	16,500 lbs.



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MORE ECONOMICAL DRILLING

"OILWELL" SUPER SWIVEL

. . . designed for the requirements of tomorrow, providing an extra factor of safety for the highest speeds and greatest depths of today.

Dead-load Capacity	(tons)	400
Maximum Recommended Drilling Depths		
with 4½" - 18 # Drill Pipe: 100 r.p.m.	(feet)	17,000
200 r.p.m.	(feet)	14,000
400 r.p.m.	(feet)	11,000
Fully Streamlined Fluid Passage, Diameter	(inches)	4
Body, A.P.I. Left-hand Tool-joint Threads	(inches)	7⅝
Wash Pipe, faced Inside and Outside		DI-HARD
Weight, Complete less Hose Connection	(pounds)	4,800

"OILWELL" 21-INCH SUPER-SPEED ROTARY

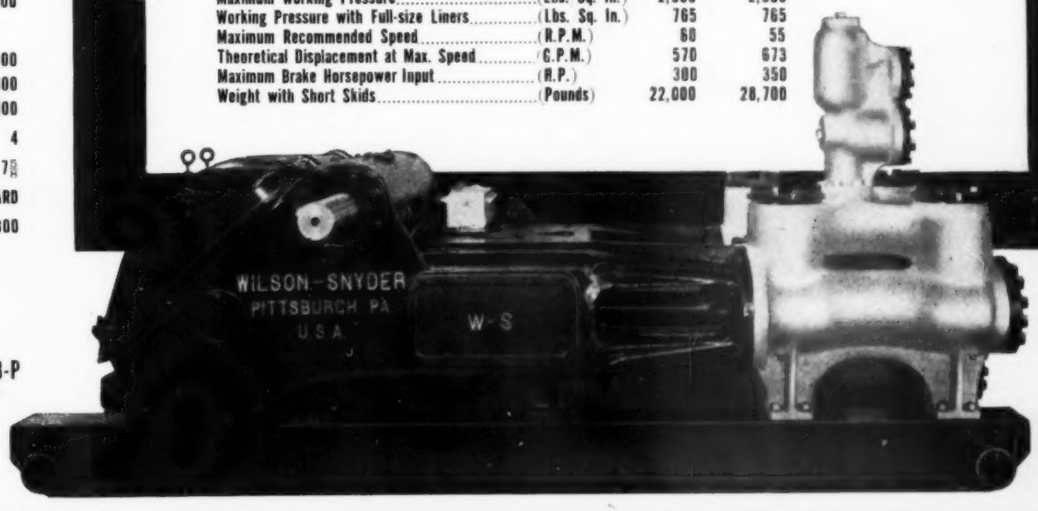
. . . designed, constructed and tested for 1,000 r.p.m. operation. Fully heat-treated, spiral-bevel gearing with surface-hardened pinion. Self-centering, angle-contact main bearing with high-precision balls of large diameter and surface-hardened, heat-treated and ground, alloy-steel races. Positive forced-feed and circulating-oilbath lubrication.

Rated Supportable Dead-load Capacity	(tons)	300
Maximum Recommended Drilling Depth	(feet)	17,000
Gear Ratio		2.61 : 1
Weight, Complete less Drive Bushing	(pounds)	9,624

"OILWELL" NO. 14P-HD AND WILSON-SNYDER NO. 18-P POWER SLUSH PUMPS

. . . sturdier power pumps for the more severe drilling requirements. Both pumps are built for efficient and reliable performance over a wide range of operating conditions.

		No. 14P-HD	No. 18-P
Maximum Liner Size by Stroke	(Inches)	7¼" x 14"	7¼ x 18"
Hydraulic Test Pressure, Discharge	(Lbs. Sq. In.)	4,000	4,000
Maximum Working Pressure	(Lbs. Sq. In.)	2,500	2,500
Working Pressure with Full-size Liners	(Lbs. Sq. In.)	765	765
Maximum Recommended Speed	(R.P.M.)	60	55
Theoretical Displacement at Max. Speed	(G.P.M.)	570	673
Maximum Brake Horsepower Input	(H.P.)	300	350
Weight with Short Skids	(Pounds)	22,000	28,700



WILSON-SNYDER NO. 18-P
POWER SLUSH PUMP

OIL WELL SUPPLY COMPANY

FIELD OPERATING DATA — VENEZUELA

	Northern Fields (Ambrosia, La Rosa, and Punta Penitez)	Tia Juana	Lagunillas	Quiriquire	Jusepin	Cumarebo	Pedernales	Temblador	San Joaquin
Rigs in operation, July 1, 1940	1 rotary	1 rotary	none	none	6 rotary	none	none	none	6 rotary
Size derricks	122 ft. x 24 ft.	122 ft. x 24 ft.	122 ft. x 24 ft.	122 ft. x 24 ft.	129 ft. x 24 ft.	122 ft. x 24 ft.	129 ft. x 24 ft.	122 ft. x 24 ft.	136 ft. x 26 ft.
Size drawworks	3-shaft, 4-speed 9-in. drum shaft 7½-in. line and jack shaft	3-shaft, 4-speed 9-in. drum shaft 7½-in. line and jack shaft	3-shaft, 4-speed 9-in. drum shaft 7½-in. line and jack shaft	5½-in. shaft, 3-speed roller bearing	7½-in. drum shaft, 3-speed	5½-in. shaft, 3-speed roller bearing	7½-in. shaft, 3-speed roller bearing	7-in. shaft, 3-speed roller bearing	9-in. shaft, 4-speed roller bearing
Standby drawworks	none	none	none	none	none	none	none	none	none
Drilling line	1⅛-in. 6x19	1⅛-in. 6x19	1⅛-in. 6x19	1-in.	1-in.	1-in.	1-in.	1-in.	1⅛-in.
No. of drilling lines strung	6	6	6	6	6	6	6	6	8
Prime mover	12x12 horizontal twin steam	12x12 horizontal twin steam	12x12 horizontal twin steam	12x12 horizontal twin steam	12x12 horizontal twin steam	12x12 horizontal twin steam	12x12 horizontal twin steam	12x12 horizontal twin steam	12x12 horizontal twin steam
Boilers	3 to 4	3 to 4	3 to 4	3	3	3	3	3	4
Horsepower per boiler	125	125	125	125	125	125	125	125	125
Working pressure	300 lb. per sq. in.	300 lb. per sq. in	300 lb. per sq. in.	.....	.....	.....	.....	.....	.....
Water supply	Plentiful	Plentiful	Plentiful	Plentiful	Plentiful	Plentiful	Plentiful	Plentiful	Plentiful
Treatment	none	none	none	none	none	none	none	none	none
Average weight on bit	2 to 4 tons	2 to 4 tons	2 to 4 tons	3½ tons	6½ tons	4 3/5 tons	4 tons	5 tons	3½ tons
Average rotary table speed	150 r.p.m.	150 r.p.m.	150 r.p.m.	110 r.p.m.	90 r.p.m.	100 r.p.m.	90 r.p.m.	100 r.p.m.	90 r.p.m.
Size drill pipe	5³⁄₁₆-in. FH or 4½-in. EU-IF	5³⁄₁₆-in. FH or 4½-in. EU-IF	5³⁄₁₆-in. FH or 4½-in. EU-IF	4½-in. API-FH	4½-in. API-FH	4½-in. API-FH	4½-in. API-FH	4½-in. API-FH	4½-in. API-FH
Average service life	60 wells	60 wells	60 wells	25 wells	20 wells	30 wells	20 wells	20 wells	75,000 ft.
Size tool joints	same as drill pipe above	same as drill pipe above	same as drill pipe above	same as drill pipe above	same as drill pipe above	same as drill pipe above	same as drill pipe above	same as drill pipe above	same as drill pipe above
Average service life	60 wells	60 wells	60 wells	25 wells	20 wells	30 wells	20 wells	20 wells	75,000 ft.
Drill collar	28 ft. 5³⁄₁₆-in. 2725 lb.	28 ft. 5³⁄₁₆-in. 2725 lb.	28 ft. 5³⁄₁₆-in. 2725 lb.	5¾-in. O.D. 30-ft. lengtn 71 lb./ft.	3 of 5¾-in. O.D. 30-ft. length 71 lb./ft.	One 5¾-in. O.D. 30-ft. length 71 lb./ft.	5¾-in. O.D. 30-ft. length 71 lb./ft.	5¾-in. O.D. 30-ft. length 71 lb./ft.	3 of 6⅝-in. O.D 30-ft. length 97 lb./ft.
	20 ft. 4½-in. 569 lb.	20 ft. 4½-in. 569 lb.	20 ft. 4½-in. 569 lb.	....	....	....	....	....	....
Rotary bits	4-wing drag bits	4-wing drag bits	4-wing drag bits	rock bits	rock bits	rock bits	rock bits	rock bits	rock bits
Average footage per bit	750 ft.	750 ft.	750 ft.	450 ft.	550 ft.	600 ft.	300 ft.	600 ft.	75 ft.
Mud pumps	two	two	two	two	two	two	two	two	two
Size	20-in.	20-in.	20-in.	14x7¼x18	14x7¼x18	14x7¼x18	14x7¼x18	14x7¼x18	one 20-in. one 18-in.
Average working pressure	500 lb. per sq. in.	500 lb. per sq. in.	500 lb. per sq. in.	900 lb. per sq. in.	1000 lb. per sq. in.	800 lb. per sq. in.	1000 lb. per sq. in.	900 lb. per sq. in.	1300 lb. per sq. in.
Drilling mud	Specially treated	Specially treated	Specially treated	.....	Chemicals used to reduce viscosity	.....	.....	.....	.....

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2 CR., ½ MOLY.
2 CR., ½ MOLY., 1¼ SIL.
2½ CR., ½ MOLY., ¾ SIL.
2¼ CR., 1 MOLY.
3 CR., ½ MOLY., 1¾ SIL.
3 CR., 1 MOLY.
5 CR., ½ MOLY.
5 CR., ½ MOLY., 1½ SIL.
5 CR., ½ MOLY., TITANIUM
5 CR., ½ MOLY., COLUMBIUM
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UNITED STATES STEEL

FIELD OPERATING DATA — VENEZUELA (Continued)

	Northern Fields (Ambrosia, La Rosa, and Punta Benitez)	Tia Juana	Lagunillas	Quiriquire	Jusepin	Cumarebo	Pedernales	Temblador	San Joaquin
Average weight	85-90 lb./cu. ft.	85-90 lb./cu. ft.	85-90 lb./cu. ft.	12.0 lb./gal.	13.0 lb./gal.	12.5 lb./gal.	13 lb./gal.	12 lb./gal.	11.5 lb./gal.
Average viscosity	35-40 sec. Marsh funnel	35-40 sec. Marsh funnel	35-40 sec. Marsh funnel	52 sec. Marsh funnel	60 sec. Marsh funnel	48 sec. Marsh funnel	58 sec. Marsh funnel	48 sec. Marsh funnel	55 sec. Marsh funnel
Deviation limitation	Average less than 5 deg.	Average less than 5 deg.	Average less than 5 deg.	.....	.....	.....	.....	.....	.....
Test interval	.....	.....	.....	500 ft.	1000 ft.	100 ft.	500 ft.	500 ft.	100 ft.
Mechanical coring	wire line	wire line	wire line	conventional	conventional	conventional	conventional	conventional	wire line and conventional
Well-logging	Schlumberger	Schlumberger	Schlumberger	Schlumberger	Schlumberger	Schlumberger	Schlumberger	Schlumberger	Schlumberger
	Halliburton "Jeep"	Halliburton "Jeep"	Halliburton "Jeep"	.....	Halliburton "Jeep"	.....	.....	Halliburton "Jeep"	Halliburton Jeep""
Average time to complete well	15 days	15 days	15 days	29 days	40 days	32 days	140 days	31 days	120 days
Average casing program	Combination oil string (full-hole assembly) set through sand	Combination oil string (full-hole assembly) set through sand	Combination oil string (full-hole assembly) set through sand						
	16-in. 55 lb. 120 ft.	16-in. 55 lb. 60 ft.	16-in. 55 lb. 60 ft.	13⅜-in 54.5 lb. 400 ft.	9⅝-in. 36 lb. 900 ft.	11¾-in. 54 lb. 400 ft.	18⅝-in. 78 lb. 200 ft.	9⅝-in. 40 lb. 1200 ft.	13⅜-in. 54 lb. 150 ft.
	11¾-in. 47 lb. 750 ft.	13⅜-in. 48 lb. 400 ft. or 11¾-in. 47 lb. 250 ft.	11¾-in. 47 lb. 250 ft. or 13⅜-in. 47 lb. 400 ft.	8⅝-in. 32 lb. 2700 ft.	5½-in. 15 lb. 4400 ft.	6⅝-in. 20 lb. 1500 ft.	13⅜-in. 61 lb. 1000 ft.	7-in. 22 lb. 4300 ft.	9⅝-in. 47 lb. 1500 ft.
	6⅝-in. 24 lb. 2900 ft.	8⅝-in. 36 lb. 2700 ft. or 6⅝-in. 24 lb 3400 ft.	6⅝-in. 24 lb. 4000 ft.				9⅝-in. 48 lb. 4800 ft.		5½-in. 20 lb. 6500 ft.
Liner or screen	Shop-perforated 6⅝-in. 28 lb. 100 ft. 250 ½-in. holes per ft.	6⅝-in. 28 lb. 125 ft. 250 holes per ft. or 8⅝-in. 43 lb. 250 ft. 324 holes per ft. (⅜-in.)	6⅝-in. 28 lb. 225 ft. 250 ½-in. holes per ft.	4¾-in. 16 lb. 375 ft.	.....	4¾-in. 16 lb. 125 ft.	4¾-in. 16 lb. 500 ft.	.....	.....
Acid treatment	none	none	none	none	none	none	none	none	none
Gravel-packing	none	none	none	none	none	none	none	none	none
Size of shot	none	none	none	none	none	none	none	none	none
Flowing wells	157	146	106	145	44	42	9	62	8
Average flowing life	3 to 5 years	3 to 5 years	3 to 5 years	indefinite	indefinite	indefinite	indefinite	indefinite	indefinite

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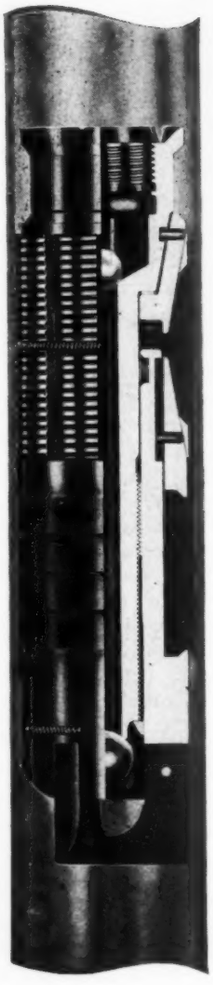
FIELD OPERATING DATA — VENEZUELA (Continued)

	Northern Fields (Ambrosia, La Rosa, and Punta Benitez)	Tia Juana	Lagunillas	Quiriquire	Jusepin	Cumarebo	Pedernales	Temblador	San Joaquin
Gas-lift-wells	16	19	79	2	none	1	none	none	none
Average gas-lift life	3 to 5 years	3 to 5 years	3 to 5 years	indefinite	.....	indefinite	.....	.....	.....
Pumping wells	130	1	198	37	none	15	none	none	none
Average depth of wells	2000 ft. 3000 ft.	2550 ft. 3450 ft.	3300 ft. 5200 ft.	2630 ft. 3260 ft.	4380 ft.	730 ft. 1650 ft.	5910 ft.	4077 ft.	6557 ft. 8975 ft.
Average gas-oil ratio	1050 cu. ft./bbl.	536 cu. ft./bbl.	389 cu. ft./bbl.	455 cu. ft./bbl.	884 cu. ft./bbl.	546 cu. ft./bbl.	692 cu. ft./bbl.	258 cu. ft./bbl.	2300 cu. ft./bbl.
Average well pressure									
Casing	.....	.....	.....	410 lb. per sq. in.	1140 lb. per sq. in.	325 lb. per sq. in.	1320 lb. per sq. in.	790 lb. per sq. in.	1960 b. per sq. in.
Tubing	125 lb. per sq. in.	245 lb. per sq. in.	140 lb. per sq. in.	170 lb. per sq. in.	620 lb. per sq. in.	185 lb. per sq. in.	840 lb. per sq. in.	425 lb. per sq. in.	1440 lb. per sq. in.
Central pumping powers	none	none	none	none	none	1	none	none	none
Average wells per power	.....	.....	.....	.....	.....	5	.....	.....	.....
Average depth of wells	.....	.....	.....	.....	.....	1400 ft.	.....	.....	.....
Pressure maintenance	none	none	none	Pressure maintenance program in operation	none	Both gas and condensate injected	none	none	none
Recycling	none	none	none	.....	none	.....	none	none	none
Secondary recovery methods	none	none	none	Repressuring	none	Repressuring	none	none	none
Character of producing formations	sand	sand	sand	sand	sand	sand	sand	snad	sand
Oil and gas separation	single-stage	single-stage	single-stage	single-stage	single-stage	single-stage	single-stage	single-stage	single-stage and multiple stage
Servicing wells	Portable equipment used	Portable equipment used	Portable equipment used	Stationary production derricks and portable pulling units	none	Portable equipment used	none	none	none
Remarks	All wells are in lake; all equipment for drilling and servicing wells is mounted on barges. Average depth of water is 60 ft.	All wells are in lake; all equipment for drilling and servicing wells is mounted on barges. Average depth of water is 60 ft.	All wells are in lake; all equipment for drilling and servicing wells is mounted on barges. Average depth of water is 60 ft.	Discovery well brought in on June, 1, 1928. Total of 296 wells in field. Gravity of crude is approximately 19.0 deg. A.P.I.	Total of 46 wells drilled as of July 1, 1940, in field. Average gravity of crude produced is approximately 32.7 deg. A.P.I. Discovery well completed October 11, 1938.	Discovery well completed April 15, 1931. Total of 118 wells in field. Average gravity of crude production is approximately 48.5 deg. A.P.I.	Discovery well completed August 11, 1935. Total of 19 wells drilled to date in field. Gravity of the crude produced is approximately 21.3 deg. A. P. I. Crude has high sulphur content.	Discovery well was completed September 21, 1936. Total of 90 wells drilled to date in field. Average gravity of crude produced is approximately 22.4 deg. A.P.I.	Discovery well completed March 4, 1939. Total of 8 wells completed in field as of July 1, 1940. Average gravity of crude produced is approximately 41.5 deg. A.P.I.

JACK SCREW
CEMENTING PACKER



Packer set in casing.

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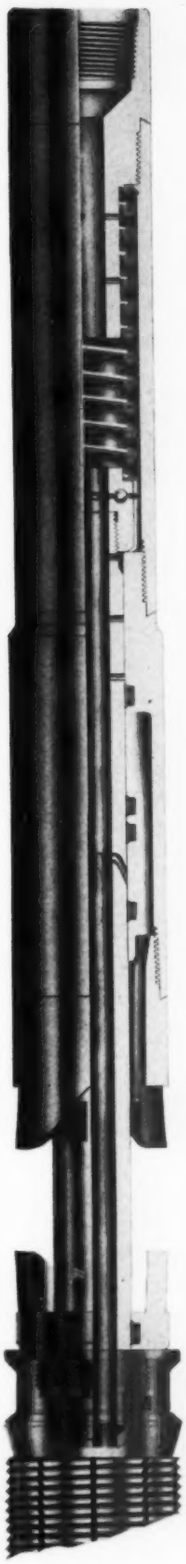

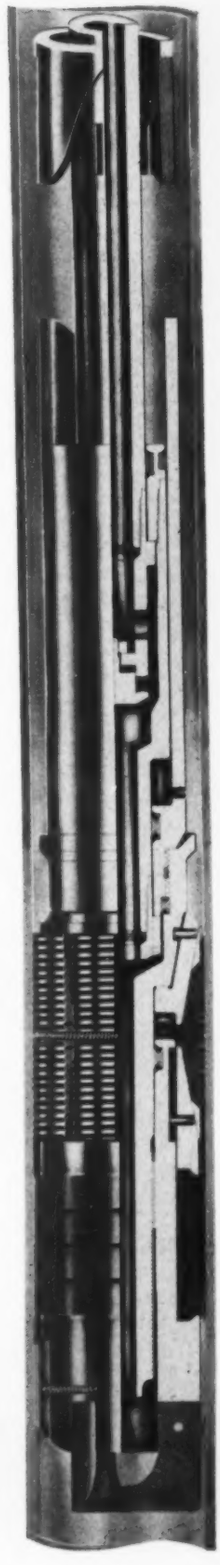

Above: By-pass valve closed; Flow Packer valve open.

Above, left: By-pass valve closed.

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Engineering Analysis of Well Performance Is Modern Basis for Gas-Lift Operation

Using gas-lift devices now available and increased knowledge of flow principles, engineers are obtaining increased efficiencies by careful studies of installations

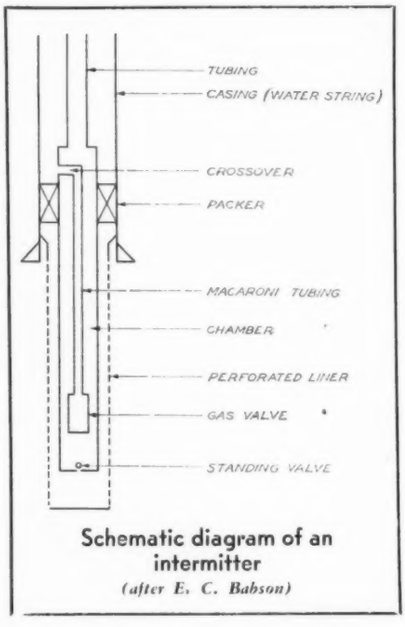
By H. LEE FLOOD
Associate Editor

OCCASIONALLY, even now after these several years, one hears or reads someone's expression of surprise that gas lift has attained the place it now occupies as one of the major oil production methods. To one who has watched the steady development of gas-lift practice during the last 13 or 14 years this attitude is in the same category with the classic query often facetiously made that concerns whether the automobile is "here to stay or is it a passing fad?"

Perhaps the "easiest" fault we humans have is that of being unduly critical. How easy it is to say, in 1940, that the gas-lift installations of 1925 and even later were crude and grossly inefficient. Yet, recalling the reactions of oil men of that day as though the present improvements in gas lift had not been made, it was really "somethin'" to see a well flowing thousands of bbl. of oil on gas lift when previously the only means of producing the well after it had ceased its natural flow would have been to lift the oil mechanically*. There may have been a few farsighted engineers who recognized the inherent inefficiency because, say, 3000 cu. ft. of gas were expended to lift a bbl. of oil instead of, say, 1000 cu. ft. But to most of the production men who installed those early open-end tubing jobs, the luxury of continuing to recover the large daily volumes of oil obtained during a well's flowing life instead of a relatively few bbl. of oil by mechanical lifting overshadowed any very serious consideration of the inefficiency involved.

Granted that those early gas lifts were crude and inefficient, yet instead of criticizing the designers of those simple installations as being entirely devoid of all engineering skill, rather let us realize that the gas lifts of that day got the job done in the spirit of the times—"get as much oil out in the shortest possible time." Whether or not that orgy of producing "with the lid off" led us into the later difficulties is beside the present point. Operators wanted more oil and the gas lift helped them get it.

The purpose of the foregoing remarks is to lay the groundwork for the statement that the designers of gas-lift equipment have never been *too* far behind the requirements of the times. When all that was wanted was more and more oil brought to the surface, gas lift filled the need. When the bottom dropped out of the market and operators had to begin watching every penny of lifting cost; when proration became the prevailing rule and daily production rates dropped to only a few bbl. of oil per day—gas-lift designers got busy and did a pretty fair job of keeping abreast of the changing order of the production picture. This statement doesn't disregard the mistakes and costly errors that have been made. Nor is it intended to convey the impression that had the requirements of 1940 prevailed in, say, 1926, that the many improvements made during the last 10 years in gas-lift devices could have been evolved overnight. Many past mistakes and wrong approaches to the problems created disfavor and distrust of gas lift that, in some instances, has only in recent years been dispelled.



Schematic diagram of an intermitter
(after E. C. Babson)

Of all the devices now available to oil production men, gas lift has probably stimulated more inventive thought and experimentation than any other. This is evidenced by the countless devices that have been patented and placed on the market. Of the many, only a few have remained. The relatively few devices and systems now available are sound and trustworthy not alone because their principles were well-founded initially. More important has been the constant thought and study, the never-ceasing testing and re-design that has accompanied the development of these present-day gas-lift systems to their current status of near-perfection.

Improvements and changes are being made constantly in the leading gas-lift implements now available. Yet it is significant that in recent months most of these changes have been in materials—a substitution of tool steel for castings, the use of alloys to resist abrasion and wear, or a change in design that reduces the cost of production and thus lowers the cost of the tool to the user.

Having perfected devices that are sound in design, gas-lift manufacturers are now recognizing fully that successful application of their equipment depends upon intelligent analysis of well performance and knowledge of the many variables that influence the success with which gas-lift may be applied to a given well.

Prospective users of gas-lift equip-

*The term "mechanical" refers to accepted methods of lifting oil other than those utilizing the energy of gas.

ment are constantly pressing the engineers with gas-lift companies to make a performance guarantee, even an unofficial estimate, of the results that may be expected from a gas-lift installation. Unless all the many factors that vary from well to well are known for a specific case, any estimate of performance is guesswork pure and simple and no intelligent engineer will venture a guess under such circumstances.

The outstanding trend in recent months, then, rather than being a change in basic design of gas-lift equipment, has been to stress the importance of intelligent analysis of well performance, both before and after a gas-lift installation has been made. The importance of this scientific, or shall we say, engineering approach to the problem is indicated by the fact that all gas-lift manufacturers, without exception, now employ capable engineers, many of whom have had a thorough training in production work, all of whom are conversant with the mathematics and physical laws that govern so largely the process of lifting oil by utilizing the energy of natural gas. Among this group are to be found some of the most exacting students in the oil industry — men who are working every day with gas lift, learning more about the peculiarities of individual wells, gaining greater knowledge of the factors that have the greatest influence on gas-lift efficiency.

The more important basic well characteristics that influence the design and performance of a specific gas-lift installation have been listed as follows[1]: (1) reservoir or static pressure; (2) productivity index; (3) formation gas-oil ratio; (4) percent water; (5) depth; (6) size and condition of casing, and (7) size and condition of liner. Except for static pressure and productivity index, these well characteristics usually can be obtained from production records.

Having utilized all available well data in reaching a decision concerning the type of gas lift to install, the number and spacing of valves, if any, in the tubing string, etc., the true appraisal of a given installation must await actual operation when the ratio of net input gas volume required per bbl. of oil may be determined. This important index has always served as the best single criterion upon which to base comparative efficiencies of gas-lift installations. The gas-oil ratio offers a direct gauge to the operator of the amount of gas required to obtain his marketable commodity, and as the cost of compressing the input gas represents a direct expense, excessive gas-oil ratios are not long tolerated.

Assuming an increasingly important place recently in the study of gas-lift application has been the consideration of the amount of back pressure imposed against the face of the producing formation. In many types of gas-lift installations, particularly when intermittent flow prevails, fluid columns are permitted to exist in the well, the weight of which acts, of course, against the formation and serves to retard the rate at which fluid enters the wellbore. Recognition of this effect is not new by any means but its importance has been stressed particularly in low-productivity index wells in which the bottom-hole pressure has declined. In some instances, the bottom-hole pressures are so low that the weight of only a few columnar ft. of fluid is enough to prevent entirely the inflow of oil.

This advantage of reducing the back-pressure against the formation has stimulated quite a number of designs and arrangements of equipment, all having the purpose of isolating the formation from any imposed pressure, whether it be the weight of a fluid column or the pressure of the input gas being utilized to flow the well.

The usual method of isolating the formation is to employ the so-called sub-packer type of installation. Essential parts are: (1) a packer, to seal-off the casing and prevent either fluid or gas pressure in the annulus being exerted against the formation, and (2) a standing valve in the lower end of the tubing or chamber, which opens to admit oil when the gas pressure is released between flows, but closes during the flow and thus prevents the high pressure imposed during the flow reaching the formation face. The general features of a sub-packer installation are shown diagrammatically in Fig. 1.

Certain types of flow valves that depend upon the differential between the weight of a fluid column and the input pressure to actuate the mechanism are not so well adapted to sub-packer pressure-free installations. Surface-controlled intermitters in which the valves are actuated mechanically may be operated without imposing any pressure against the formation whatsoever.

Recognizing the inherent value of surface controlled intermitting systems for this latter-stage low-pressure type of well, nearly every gas-lift manufacturer is now in a position to supply this type of equipment when its use is indicated. As a result of these developments, the use of gas lift has been extended to wells that formerly were believed capable of being produced economically by mechanical means only. That stripper wells may be produced profitably is a definite indication that gas lift no longer should be considered only as an intermediate stage between natural flow and mechanical lift.

Although it has been stated that flow valves are not so well suited for installations in which back pressures against the formation are undesirable, this does not mean that this type of equipment cannot be adapted to such service.

One interesting arrangement that is being used in certain wells recently employs flow valves inserted in a small-diameter, or macaroni tubing string that is installed inside the regular tubing string. The lower end of the macaroni string is bull-plugged so that the input gas pressure is confined entirely within the small tubing except, of course, when gas is admitted to the larger tubing for lifting purposes. This arrangement prevents input gas pressure being exerted against the formation, thus eliminating the need for the packer that is required when the gas is introduced between the tubing and casing.

Flow valves in a macaroni string have been used to advantage in wells that have just ceased flowing naturally and the operator prefers to not pull the tubing. The small tubing and the flow valves may be run inside the flow string and gas lift thus employed at a minimum expense of time and money.

In other instances, attempts to establish gas lift by admitting gas between the casing and tubing have disclosed that the casing leaked, permitting the gas to escape and preventing operation of the lift. The expense of squeeze-cementing or otherwise repairing the damaged casing may be avoided or temporarily postponed by employing flow valves on a macaroni string run inside the tubing. Even if the lower end of the macaroni is open, injected gas can be prevented from entering the casing and escaping, by always maintaining the fluid column in the well high enough to submerge the lower end of the larger tubing and thus provide a liquid seal.

Another fairly recent innovation

[1] "The Range of Application of Gas-Lift Methods" by E. C. Babson. A.P.I. *Drilling and Production Practice*, 1939, p. 266.

that is finding favor among users of flow valves involves the installation of bottom-hole chokes or disks in the lower end of the tubing string to control the rate of oil entering the tubing so that the allowed daily production will be obtained in a steady flow throughout the 24 hours. When the productivity index is known, the size of the choke may be selected in advance. When it is necessary to determine the correct orifice size experimentally, a series of disks may be spotted in the tubing, each containing a hole that is a size larger than the one just above it. If the upper (and smallest) orifice restricts the flow too much, the disk may be knocked-out with a tool lowered-in from the surface. Successive disks may be removed until the desired rate is obtained. Slight variations from the exact flow rate may be corrected by increasing or decreasing the pressure of the input gas.

Recent experimental work in the direction of obtaining lower gas-oil ratios has largely taken the form of restricting the volume of gas admitted until no more gas is used than is necessary to lift a given volume of oil. Inefficient operation of intermitting systems has in some instances been traced to admission of more gas than necessary to lift the oil. Full recognition of the fact that the greater amount of work done by the gas occurs as it expands rather than at its initial pressure has made it desirable to adjust the volume of gas admitted until, ideally, all energy of the admitted gas has been expended just as the work of lifting the oil to the surface has been completed.

Combinations of time-control and fluid-velocity control have been worked out now until very little gas is wasted in intermitting systems. In deep wells, often the admission of gas is terminated now long before the fluid being lifted has reached the surface. The period of admission is such that the expansion of the gas completes the work of lifting. Even in shallow wells, the capacity of large chambers or anchors often is so great that the volume of gas admitted before the required initial pressure is reached is excessive once the fluid begins to move.

In view of the current trend toward more exacting study of well characteristics and of actual gas-lift operations as the real key to more efficient utilization of this important production method, it is believed that worthwhile results can be derived in almost any given instance where one of the better-designed gas-lift systems is being used, by a closer study of every factor that influences the problem. Usually when sufficient data have been gathered and analyzed properly, the results will indicate clearly a means of improving operation of the gas lift that otherwise would not be disclosed. It is believed that many engineers are prone to become discouraged too quickly with results obtained from a given installation or setting when a little faith and intelligent analysis might indicate the trouble.

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By
WALLACE A. SAWDON
Pacific Coast and Foreign Editor

IN any well containing fluid to a considerable height there exists at the bottom of the hole a potential force that can be put to work by creating a temporary differential pressure. A powerful fluid movement will accompany the immediate equalization of the differential and this fluid movement can be utilized to clean-out sand or even heavy pieces of debris from the bottom of the hole or to wash-out perforations that may have become sanded-up or otherwise clogged. Bailers and perforation washers designed to utilize the hydrostatic pressure of a well in this manner have been employed extensively for maintenance of producing wells, for cleaning-out after shooting, for the recovery of small fish, and for numerous special applications that require removal of foreign matter from producing or drilling wells.

The force available for use depends on the distance between the point of operation and the top of the fluid in the hole and on the specific gravity of the fluid. The minimum fluid column for effective results is probably 500 ft. The hydrostatic pressure of a column of water is 0.433 lb. per sq. in. per ft. of height but for a well filled with 35-deg. A.P.I. oil the pressure would be only 0.368 lb. per sq. in. An 80-lb. per cu. ft. mud, on the other hand, would have a pressure of 0.554 lb. per sq. in. per vertical ft. A 5000-ft. well full of 35-deg. oil would, therefore, have a fluid pressure at the bottom of the hole of 1840 lb. per sq. in., whereas the same well filled with 80-lb. mud would have a fluid pressure of 2770 lb. per sq. in. The pressure exerted by any height of fluid of any specific gravity to be found in drilling or producing wells can quickly be determined from the graph accompanying an article on drilling mud found elsewhere in this issue.*

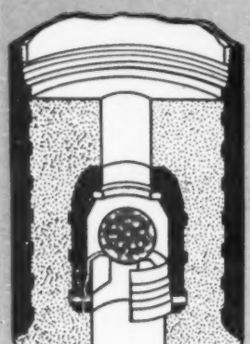
Rock bit cutters and pipe fragments (in circle) recovered with an automatic hydraulic suction bailer and junk basket

There are several differential-pressure bailers and perforation washers now available but they are all designed to establish a differential pressure at bottom, or, in the case of tools used for cleaning-out perforations, at some predetermined position in the well and thus utilize the pressure exerted by the fluid column above. Each tool consists in general of an air or suction chamber containing air at atmospheric pressure; a means for suddenly opening a valve into this chamber when the tool has reached the desired position; a load-receiving chamber, and a bottom in which is positioned a flapper valve to hold the load until the equipment returns to the surface where it may be dumped.

The differential-pressure bailer is run into the well on a sand line and is set on bottom where the valve into the air chamber is opened. As soon as this occurs, the well fluid under bottom-hole pressure rushes through the bottom and load chamber, carrying with it the material to be bailed. After

(Continued on Page 112)

*"Increased Knowledge of Mud Characteristics and Control Augments Drilling Efficiency."



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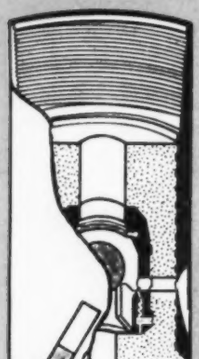

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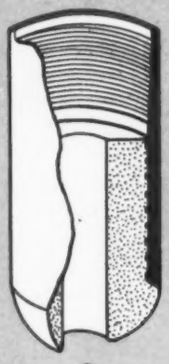

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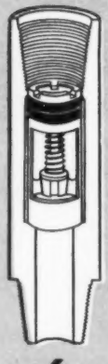

6

There is a TYPE of BAKER EQUIPMENT to Meet Every Requirement of Landing and Cementing Casing

Whether the problem is one of guiding and floating a long and heavy string of casing, or that of landing and cementing a string in shallow depths, there is a type of Baker Cement Guiding, Floating, Cementing Equipment to do the job... and do it SAFELY, EFFICIENTLY and ECONOMICALLY.

BAKER CEMENT FLOAT SHOE

As illustrated in Fig. 1 the internal construction of the Baker Cement Float Shoe consists entirely of Baker-Formula Concrete and a small amount of Bakelite... which are easily drilled up and circulated out of the hole. It is also provided with the efficient Baker BALL-TYPE Valve, with buoyant Bakelite Ball, which instantly double-seals against a narrow rubber seat at the slightest reversal of pressure. Like all Baker Floating Units, it combines in a perfectly balanced combination the three Baker features of STRENGTH —VALVE EFFICIENCY—DRILLABILITY.

BAKER CEMENT WASH-DOWN WHIRLER FLOAT SHOE

This shoe (Fig. 2), the most efficient cementing unit of its kind yet devised, embodies all of the features essential for the successful landing and cementing of casing. It safely and efficiently accomplishes the following RESULTS: 1. GUIDING is easily and efficiently done, due to the rounded nose of the concrete guide which leads the casing past all side wall irregularities. 2. FLOATING is safely performed, due to the BALL-TYPE Back Pressure Valve, which provides a leak-proof seal against either high or low pressure and affords strength beyond the collapsing point of the casing. 3. REMOVING BRIDGES and WASHING DOWN is accomplished by the downward, hydraulicking action of the circulating fluid through the baffled "Down-Whirler" ports. 4. WASHING FORMATION at and above the cementing point effectively conditions the wall of the hole preparatory to the final cementing operation. 5. BETTER CEMENTING is accomplished by the definite DOWNWARD, as well as UPWARD, whirling action imparted to the cement in its travel around the shoe and upward around the casing... this action insures best possible encasement of the pipe with a uniform body of cement... minimizing channeling. 6. DRILLABILITY is always assured, as the internal construction of this unit consists entirely of Baker-Formula Concrete and a small amount of Bakelite, which are easily drilled up into small, harmless fragments and circulated out of the hole.

BAKER CEMENT GUIDE CASING SHOE

The internal construction of this unit (Fig. 3) consists entirely of Baker-Formula Concrete, providing the important advantages of Strength and Drillability. It is usually used in combination with one or more Baker Cement Float Collars.

BAKER CEMENT FLOAT COLLAR

Many operators, when setting casing, prefer to have the principal "float valve" in a Collar, positioned one or two joints from the bottom... and the Baker Cement Float Collar (Fig. 4) provides this feature. It also serves as a stop for the cementing plugs, thus retaining cement tailings inside the casing and insuring a better consistency of cement outside of the shoe and casing.

This unit has the same internal construction as the Baker Cement Float Shoe.

BAKER CEMENT WHIRLER FLOAT COLLAR *with* SOLID BOTTOM BAFFLE *with* METAL "PETAL" BASKET

This unit (Fig. 5) provides a means of cementing casing any desired depth and is widely used for cementing combination strings. A solid concrete baffle stops the cement and forces it out through the baffled side ports and up and around the casing with a whirling motion. With Bakelite Ball-Type Valve Assembly and internal construction consisting entirely of concrete and Bakelite, this unit possesses the important features of Strength, Valve Efficiency and Drillability. The Metal "Petal" Basket with which this unit is equipped serves as an outside packer or barrier during the cementing job. It also protects the formation from cement contamination and cavings, as well as prevents any dissipation of the cement slurry.

The Baker Metal "Petal" Basket can be furnished as a separate unit assembled on a ring suitable for welding on casing, joints, or nipples in the field; or can be furnished as an integral part of a Basket Assembly Unit, such as illustrated in Fig. 5.

BAKER OIL TOOLS, INC.

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Los Angeles, California.
CENTRAL DIVISION OFFICE AND FACTORY:
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EXPORT SALES OFFICE:
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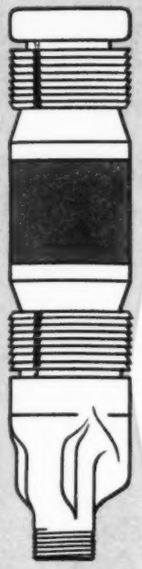
Practical and D

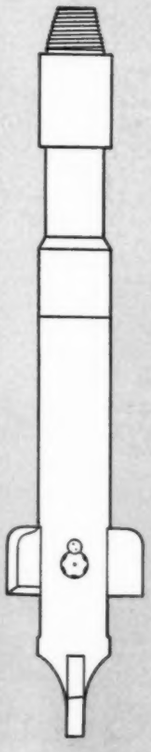
BAKER OIL T



7

IMPORTANT CEMENT RETAINER APPLICATIONS INCLUDE:

Squeeze Jobs
Re-Cementing
Cementing Behind Sections of Pipe
Reducing Gas/Oil Ratios
Series Cementing
Plugging Off Bottom Fluids
Plugging Back to Upper Zones
Testing Upper Cased Formations
As a Heaving Plug
As Bridge Plug
at any Place in Casing or Liner
All Kinds of Repair Work
in Drilling or Producing Wells
Where Casing is in the Hole



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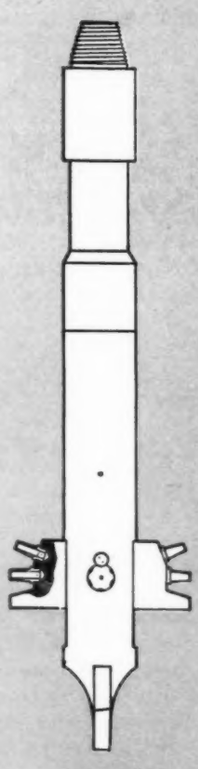


9

Dependable TOOLS

BAKER BAKWIK *Model* "B" DRILL PIPE FLOAT

The Baker Bakwik Model "B" Drill Pipe Float with Model "B" Valve Assembly (Fig. 6), provides the many advantages of a back-pressure valve in the drilling string with a Valve Assembly constructed entirely without threads, being held in position by the tool joint pin above it. The Valve Assembly is so designed as to provide positive and instantaneous sealing, assuring long life and maximum protection against costly and dangerous by-passing.

BAKER *Model* "K" CEMENT "RETAINER"

The Baker Cement "Retainer" (Fig. 7) solves many usual and unusual cementing problems by providing a sure and safe means of placing cement through tubing or drill pipe at the point where it will really be effective around the shoe; at any pre-determined location behind casing or liner; or in open hole immediately below the pipe. It minimizes the danger of sticking or plugging tubing or drill pipe by the "tubing" method of cementing; it is adaptable to any pressures, and is particularly suitable when circulation is difficult or impossible to obtain.

BAKER ROTARY WALL SCRAPER

This tool (Fig. 8) provides a safe, efficient means of enlarging the walls of an open hole to a diameter considerably greater than the casing or hole through which the tool is run. Its outstanding features are Strength and an Amazing Reaming Capacity.

Efficient applications for the Baker Wall Scraper include: Setting Liners; Setting Cement Plugs; Bottlenecking for Cementing Purposes; Enlarging Holes for Casing; Enlarging Holes for Gravel Packing; Straightening Holes; Fishing Jobs; Water Shut-Off Tests; Removing Sections of Drillable Pipe... AND Taking Cores from Side Walls of a Previously Drilled Hole by Substituting Sampler Blades for the Regular Scraper Blades. This converts the Wall Scraper into a Baker Wall Sampler which is described below.

BAKER ROTARY WALL SAMPLER

With this device (See Fig. 9) it is possible to take actual cores from the side walls of any uncased hole at any depth and thus open up new opportunities for restoring lost core records, or for checking formations which were not cored when drilled through. It also provides a positive means of checking interesting zones brought out by electrical coring methods.

DOUBLE-VALUE FOR YOUR MONEY

The Baker Wall Scraper consists essentially of a Baker Wall Scraper Assembly except that a special set of Wall Sampler Blades, containing core taking tubes, are used in place of the normal cutting blades of the Wall Scraper. Thus, the Wall Scraper and Wall Sampler are really "Two-Tools-in-One," a combination that means double-value for your money.

FOR COMPLETE INFORMATION ON THESE AS WELL AS OTHER "PRACTICAL AND DEPENDABLE" OIL TOOLS, REFER TO OR SEND FOR THE FOLLOWING:

★ Baker Section of the 1940 Composite Catalog, containing 60 pages of informative text matter and illustrations covering the entire Baker Line of Equipment.

★ Individual 1940 Baker Catalog (a reprint of the Baker Section in the Composite Catalog).

★ Baker Sections in the 1939-1940 Drilling Equipment Directory.

★ Baker Broadcast No. 17-A, a comprehensive 40-page treatise describing and illustrating the many important field applications for the Baker Model "K" Cement "Retainer".

★ Baker Cement "Retainer" News Service... a quarterly bulletin Service of successful operating ideas involving the Baker Cement "Retainer" and its latest applications.

★ Baker Broadcast No. 19, giving complete information covering the many practical applications for the Baker Wall Scraper and Baker Wall Sampler. It contains 40 pages of detailed information and illustrations and should be in your reference file.

(*Continued from Page* 109)

the air chamber has been filled, equilibrium is re-established, fluid movement ceases, and the flapper valve closes. This flapper valve traps the load for return to the surface where it may be dumped. To avoid the danger of explosion when carried to the surface, a relief valve bleeds the pressure down as the tool is withdrawn from the well and retains only sufficient pressure to dump the load automatically when it reaches the derrick floor.

Three general designs of hydraulic bailers are on the market at the present time. The principal characteristics of each are as follows:

The *rod type* is constructed with a rod running through the air or suction chamber. The upper end of this rod extends through a packing gland at the upper end of the air chamber and the lower end passes through a valve seat at the bottom of the chamber. On the lower end of the rod is a ball valve that is kept seated by an upward strain maintained on the rod by a stout string. When the bailer reaches bottom the valve is forced downward off its seat by the impact of the lower end of a set of tubular jars that are run above the air chamber.

In the *disk type* a breakable disk is used to seal the air chamber. This disk is shattered by mechanical means when the bailer is set on bottom.

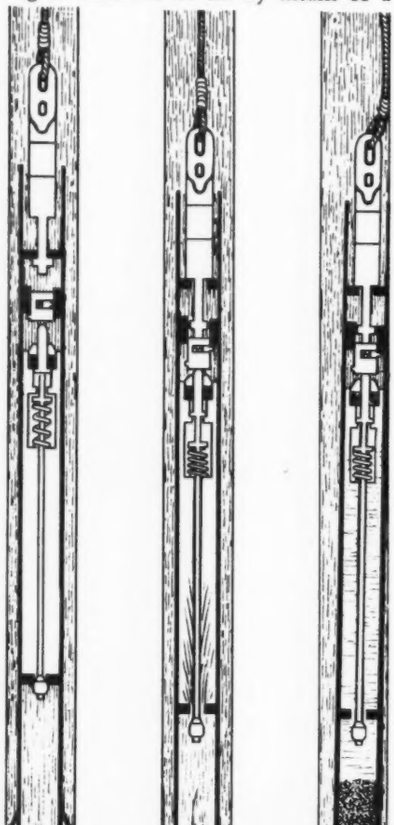
The *valve-section* type is made with a short sleeve comprising two members telescopically mounted to seal the air chamber. The sections are telescoped by weight of the air chamber when the tool is set on bottom, causing the valve into the air chamber to open.

An important point in the design of both pressure-differential bailers and perforation washers is the provision of an effective sealing mechanism for the air chamber. Such a mechanism must insure a seal against high pressures as any leakage into the air chamber while running-in will decrease the suction efficiency of the tool. There is usually a certain amount of sand in suspension in the fluid in the hole and the abrasive action of the sand will tend to scour and cut the valve and seat surfaces. In some wells acid conditions are encountered that attack and corrode even stainless steel. As hydraulic bailers and perforation washers are made in sizes as small as 1¾ in. O.D., the designer is further faced with the problem of incorporating all necessary mechanism into a very small bore without sacrificing the strength required to withstand severe service. Modern developments in alloy steels and methods of heat treating have, however, materially aided in the development of this type of equipment and it is now possible to obtain a strength that was totally unavailable a few years ago.

Although hydraulic bailers were originally developed for the removal of sand, mud, and other detrital material from the bottom of the hole, two other functions evolved with their use —fishing and perforation washing.

Small pieces of iron or steel millings, cutters off bits, pieces of broken slips, and many other small pieces of foreign matter are readily sucked into the hydraulic bailer when it loads and this makes it an effective fishing tool for junk. Special fishing tools must, of course, be used to recover a large fish but it is frequently advantageous to clean-out around a fish with a bailer before running the regular fishing tools.

It has been found possible, moreover, to recover pieces of junk weighing as much as 20 lb. by means of a fishing or junk basket that can be screwed onto the bottom of a differential-pressure bailer in place of the shoe regularly used in bailings. The junk basket is larger in diameter than the body of the bailer; on the inside of the basket a number of flat springs are riveted with their upper ends bent toward the center of the basket. When the bailer loads, the flow of fluid carries the fish past the springs, which return to their normal shape after the fish has been forced past them and retains the junk or other material for removal at the surface. The type and volume of junk that is frequently recovered from a well is shown in an accompanying illustration.



In A the hydraulic bailer is approaching bottom. In B the air chamber valve is open and loading action has begun. In C the flapper valve at bottom has closed and the load is ready to be pulled to the surface

There is a certain amount of flushing action of fluid back and forth through perforations in a well when a pressure-differential bailer loads. By means of attachments to the hydraulic bailer this action can be concentrated on a certain desired area of the perforations and the bailer thus converted into an effective perforation washer.

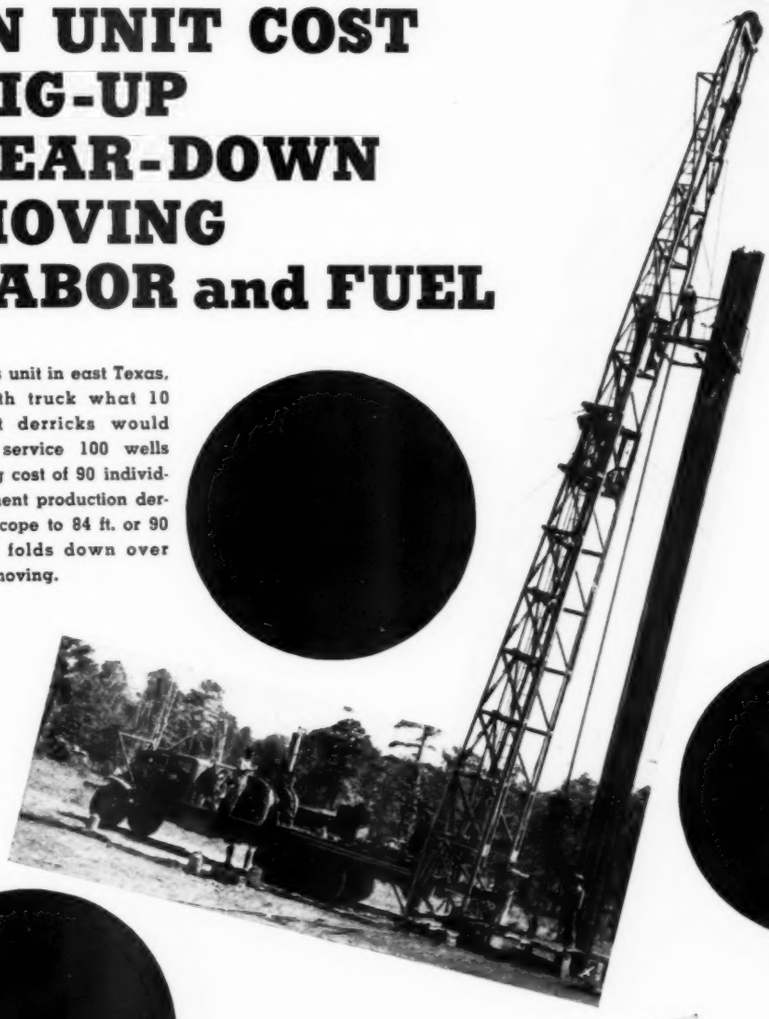
Two attachments being used to convert one type of pressure-differential bailer into a perforation washer are an "uptrip device" and a "packoff shoe." The uptrip device utilizes a well-drag element that provides for opening the valve into the air chamber by an upward movement of the tool and thus loading at any predetermined depth in the well. The packoff shoe consists of two packers mounted on a hollow mandrel and so arranged that fluid entering the air chamber must come from the confined space between the packers. With this attachment it is necessary that fluid entering the bailer must first pass out through the perforations above the upper packer, thence down the annular space between the pipe and the formation, and then through the perforations into the confined space between the packers. The washing effect obtained by the flushing action of the fluid back and forth through the perforations cleans the perforations and will generally result in an increase of production.

A pressure-differential tool is also being used for washing screen pipe. The mesh in wire-wrapped screen is so fine that it is almost impossible to pull sand from behind it. It is necessary, therefore, to drive the sand away from the wall of the liner and this driving effect is accomplished by allowing the air chamber to fill from a point above a packer that is supported by slips. The fluid column is thus given a velocity downward and this velocity is suddenly checked when the air chamber has become filled. The pressure waves set up in the fluid are stopped at the packer and diverted through the screen against the formation.

Effect Savings

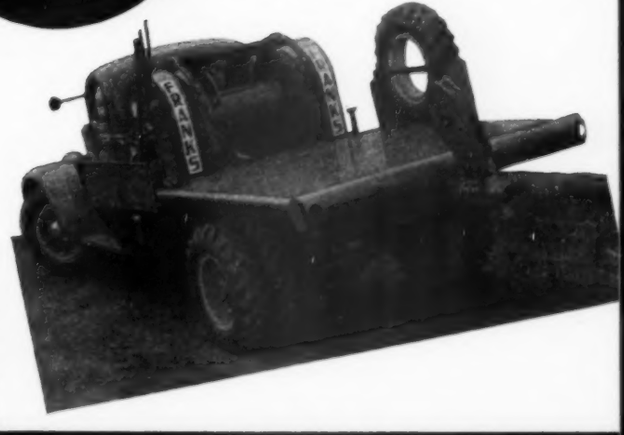
- **IN UNIT COST**
- **RIG-UP**
- **TEAR-DOWN**
- **MOVING**
- **LABOR and FUEL**

One Franks unit in east Texas, costing with truck what 10 permanent derricks would cost, will service 100 wells thus saving cost of 90 individual permanent production derricks. Telescope to 84 ft. or 90 ft. Derrick folds down over truck for moving.



ABOVE: Unit for exploratory and "Slim-Hole" production drilling to 5,000 ft. Derrick, drawworks, pumps, power plant, rotary table all unitized on truck. Derrick folds over truck for moving. Also skid models, with capacities to 8,500 ft.

BELOW: Truck mounted servicing winch, with motor used for power. Final friction drive drum. Horizontal telescoping boom eliminates floor block and provides faster anchorage and least hold down expense. Also skid winches. Capacities 1,000 to 10,000 ft.



Franks final friction drive spudder units, with or without mast all unitized on truck. Single or double drum. Also skid models. Capacities 1,000 to 10,000 ft.

FRANKS A PIONEER . . .

Franks Pioneered 100% portable drilling units on wheels, "Slim-Hole" drilling units, a perfected power take-off, and final friction drive servicing winches. Recently Franks has pioneered telescoping servicing derricks on wheels.

Franks has always kept in the lead, with improvements as far ahead as were the original units at the time they were pioneered. For further information see the Composite Catalog or write to Franks.

This gun-perforating skid unit is being hauled by barge on a river in Venezuela. The current is sometimes so swift that the men have to get into the stream and pull the barge with cables

—(Photo courtesy Lane-Wells Company.)

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
WALLACE A. SAWDON
Pacific Coast and Foreign Editor

Gun-Perforating Technique Helps Solve Diverse Production Problems

Whether the problem involves new wells or old, whenever access through casing into the formation is required, as in so many modern production methods, gun perforations will usually fill the need

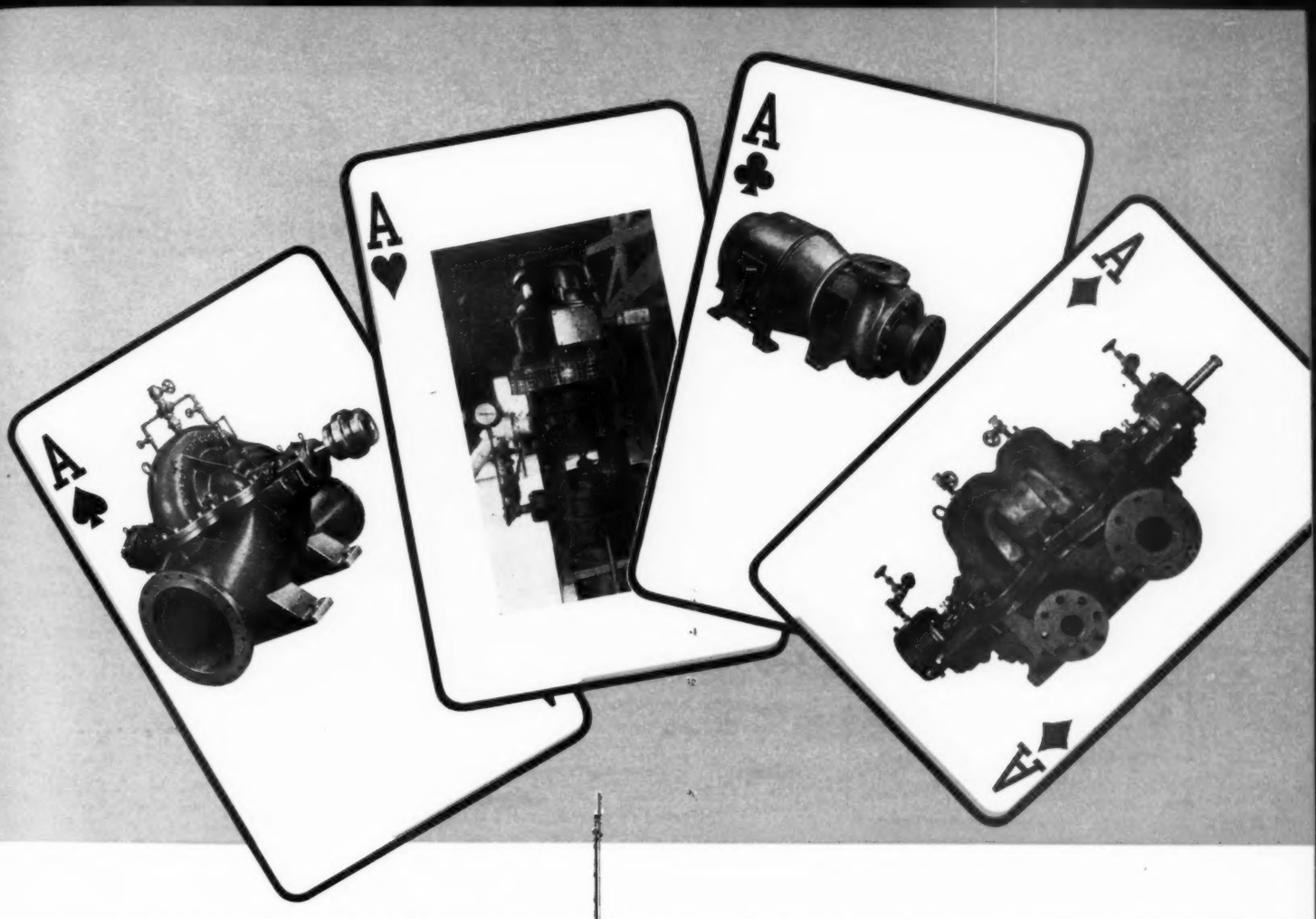
BEGINNING in 1933 when the gun perforator was first employed to revive old producing wells, the widespread acceptance of this tool has increased its scope of utility so materially through the intervening years that it has definitely influenced the completion methods being followed in many oil fields. It is now extensively employed for well completion and remedial work and the equipment for shooting holes through casing and cement has been made available in active oil areas all over the world. Gun-perforating operations in the United States and in a few foreign countries are conducted principally by service departments of the manufacturer but in a number of countries the equipment is owned and operated by the oil companies.

The gun perforator is an electrically controlled device that is lowered into the well to a predetermined position and there shoots steel bullets through the casing and its encasing sheath of cement. The bullets most widely used are from 0.45-in. to 0.50-in. diameter but smaller and larger ones are available for special purposes. Used most extensively is the sharp-nose type bullet that creates a hole as nearly clean-cut as possible through the pipe, but occasionally operators prefer to use the type bullet that will tend to rip the liner as it penetrates. Gun perforations are often made through more than one string of pipe, even when the annular spaces are filled with cement.

Specific uses of gun perforating are brought out in several other articles in this issue of *The Petroleum Engineer* and it is quite evident that the process facilitates greatly the completion and repair of wells under certain conditions. Perforating blank pipe that is cemented solidly through a series of zones or a thick, fingered formation has become common practice when exact location of the best production is not certain. This method of selective completion is usually begun at the bottom of the sections to be tested so that any perforated strata that show water or are otherwise undesirable can be squeeze-cemented and the next higher prospective location—usually determined from the electric log or cores—is then gun-perforated for a test.

A 6⅝-in. gun on walk after perforating pipe in a well in Canada. The rotary hose is connected to the casing to establish circulation after shooting

In many instances it is desirable to cement casing or liner through an oil zone and a gas sand lying immediately above. The casing opposite the oil sand only can then be gun-perforated to obtain oil production without incurring high gas-oil ratios. At a later date, when flow decreases or stops, the gas zone can be gun-perforated to per-



A WINNING HAND IN ANY NATURAL GASOLINE PLANT

A BYRON JACKSON TYPE S PUMP — *Description:* Horizontal, double-suction, split case. Suction and discharge nozzles are cast integral with lower half. Removal of the upper half of the casing permits access to the interior for inspection without disturbing piping connections or pump alignment. *Application:* General cold or warm liquid pumping service. *Standard Materials:* Cast iron, bronze fitted. *Capacity Range:* 50 g.p.m. up. *Head Range:* 40-400 ft.

A BYRON JACKSON HYDROPRESS—*Description:* Vertical split inner volute case surrounded by outer case, with pumped liquid at discharge pressure between inner and outer cases. Single circular flanged joint on outer case forms only high pressure joint in pump. Single stuffing box at suction pressure only. Vertical shaft reduces bearing loads to negligible quantities. Inner volute split case feature permits complete assembly of rotating element in shop, with minimum possible field work. *Application:* General low capacity high-head pumping service, either hot or cold liquids. *Standard Materials:* Electric welded steel or forged outer case; semi-steel inner volute case; bronze fitted with stainless steel shaft. Special materials available to meet service requirements. *Capacity Range:* 10-200 g.p.m. *Head Range:* 200-7000 feet.

A BYRON JACKSON BILTON PUMP—*Description:* Single stage, single suction; close-coupled to motor with common pump and motor shaft carried on ball bearings. Discharge nozzle may be turned in four positions. *Application:* General cold or warm pumping. *Type of Driver:* Motor only, furnished as part of pump. *Standard Materials:* Cast iron, bronze fitted. *Capacity Range:* 10-1500 g.p.m. *Head Range:* 10-300 feet.

A BYRON JACKSON STANDARD MULTIPLEX PUMP — Type SD — *Description:* Horizontal, multi-stage, split case with integral cross-overs. Impellers mounted back-to-back to equalize thrust. Residual axial forces eliminated by patented hub-ring construction without use of balancing devices. *Application:* General high head pumping service. *Standard Materials:* Cast iron, bronze fitted. *Capacity Range:* 50-4000 g.p.m. *Head Range:* 100-1000 feet.

Detailed Bulletins are Available upon Request

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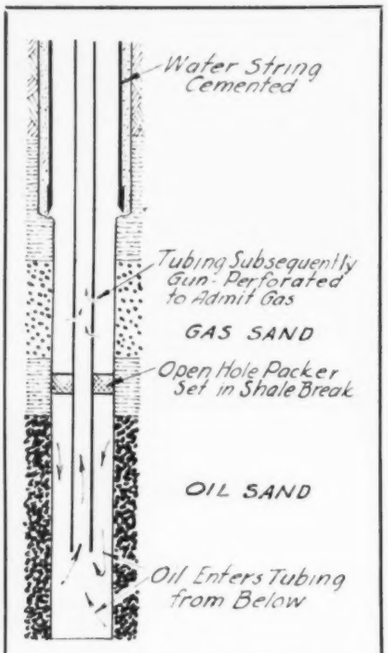
Water String Cemented
Tubing Subsequently Gun-Perforated to Admit Gas
GAS SAND
Open Hole Packer Set in Shale Break
OIL SAND
Oil Enters Tubing from Below

Fig. 1. Showing tubing gun-perforated to admit gas

mit entry of gas in any necessary amount to lift the oil. Guns are now being provided small enough to run in tubing and when open-hole packers have been used to separate gas and oil without having installed a choke in the tubing and it is desired to admit gas to lift the oil without disturbing the packer setting, the procedure shown in Fig. 1 can be followed.

Multiple-zone completions for either segregating the oil from different zones or producing from all zones together may be made by cementing the casing or liner solidly through all zones and then gun perforating at the zones.

Plugging-back to upper production has long been facilitated by the gun perforator. When the pipe has previously been thoroughly cemented through the upper sand, a bridging plug placed below this zone will shut-off all bottom influence. Even in such cases it should be made certain that water from above cannot reach the oil zone. The pipe above the zone will often have to be squeeze-cemented by gun-perforating holes for the purpose and cementing before the productive zone is shot.

When casing through the new upper zone has not previously been cemented, cement will usually be required both above and below the zone and, unless desired otherwise by the operator, through the zone itself. If the oil-bearing formation is a comparatively thin section, holes can be gun-perforated in the casing just below the sand and up through the zone to a point far enough above to protect the oil sand from upper water. Danger of channeling, however, frequently makes it uncertain that the top portion of the cement job will be good at what is usually the most important point and a squeeze job both below and above the zone will generally be advisable.

If it is desired to cement through the sand, the lower squeeze job can be carried up to the holes provided for the upper cement. When the second job is to be performed immediately after the first is completed little care has to be taken in keeping the upper hole open. Otherwise it is sometimes best to perforate holes for flow of cement back into the liner or casing and shoot other holes above these for discharge of the cement in the second job. Under some conditions the upper holes are not perforated until after the first job is completed and no outlet is provided for any return into the casing during the first job. The use of cement retainers in performing the squeeze jobs through gun-perforated holes is illustrated in Fig. 2. After the hole is cleaned out, the pipe and cement through the productive zone are gun-perforated. When the oil zone consists of more than one stratum the selective completion method of gun perforating can be used. In cases of this kind the lower retainer is usually left in the hole and the gun set down on it to position it for the first series of shots.

Squeeze-cementing behind casing or

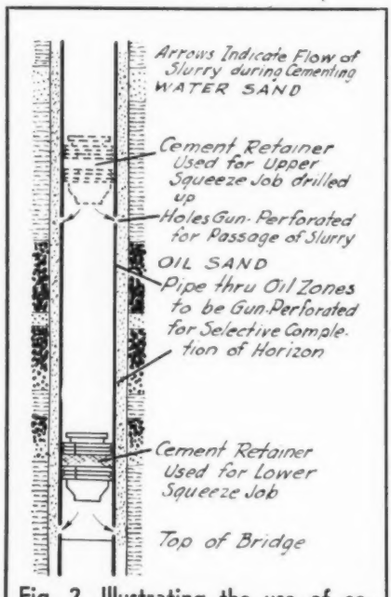
Arrows Indicate Flow of Slurry during Cementing
WATER SAND
Cement Retainer Used for Upper Squeeze Job drilled up
Holes Gun-Perforated for Passage of Slurry
OIL SAND
Pipe thru Oil Zones to be Gun-Perforated for Selective Completion of Horizon
Cement Retainer Used for Lower Squeeze Job
Top of Bridge

Fig. 2. Illustrating the use of cement retainers in performing squeeze jobs through gun-perforated holes

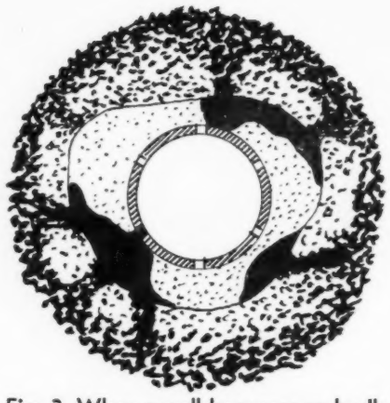

Fig. 3. When a well becomes so badly clogged that the liner or screened pipe cannot be cleaned, gun-perforating is employed to re-establish production

liner has been found effective for many purposes in remedial work and the gun perforator is an important aid in such jobs by providing the necessary holes in the pipe for discharge of the cement. Shutting-off water up the pipe is one of the chief objects of the operation but the cementing-off of gas above an oil sand is frequently done in this manner.

Considerable success has attended the gun perforating of lime formations before acidizing. By comparing production obtained in offset wells where one was gun-perforated and the other was not, an increase of production when using the gun has rather consistently been found. The bullets fracture the lime and provide a greater surface on which the acid can act. Holes have usually been spaced approximately 1 ft. apart for this work although well conditions will obviously govern the number and distance between holes.

The first gun-perforating job was for the purpose of shooting holes through a clogged liner in an old well that was to be abandoned. In many wells that have been on production for a long time the liner or screened pipe has frequently become so clogged that it cannot be either cleaned or pulled. In Fig. 3 is indicated the foreign matter, sludge, B.S., etc., as it sometimes collects with sloughed sand to clog the openings in the pipe and shut-off either completely or in part the passage of oil. The sand beyond the face of the bore will also become contaminated and clogged to an extent governed by the character of the sand and oil in the well. Results obtained by gun-perforating badly clogged liner or screened pipe have demonstrated the efficiency of this practice for increasing or re-establishing production.

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Prepacked Liners Broaden Scope of Gravel-Packing Applications

Gravel may be placed in the well or prepacked in a screened liner—multiple-zone screening in slim-hole casing now possible

By
WALLACE A. SAWDON
Pacific Coast and Foreign Editor

THE advantage of encasing a liner through the productive zone with gravel when the oil sand makes any considerable amount of sand has been proved by the results obtained in many fields of the United States. Placement of the gravel around the liner after the latter has been run into the hole was the general method used until the development of the prepacked gravel liner, which provides for inserting the liner and the gravel into the well in one operation. Regardless of the respective merits of these two methods of gravel packing, the prepacked liner probably offers the most economical means of gravel-packing wells in remote territories in many parts of the world where lack of materials and facilities for placing the gravel would otherwise make gravel-packing operations unwarranted.

Gravel packing through a productive zone or zones is done primarily to eliminate the production of sand with the oil and thus reduce sand troubles, the hazard of liner collapse, and the abrasive action of the sand on equipment.

When the gravel is placed around the liner by circulation after the pipe is in place, a larger hole can be used and greater drainage obtained. Because of this and other advantages, some operators prefer the placement method of gravel packing their wells when the right type of gravel and the mechanical means for its placement are available.

When gravel packing the liner in the well, the hole through the sand is wall-scraped to a diameter sometimes as great as 20 in. and the gravel, mixed with mud fluid, is poured or pumped into the well through the casing and down around the outside of the liner. The gravel builds-up around the pipe until it attains a predetermined height, frequently the shoe of the water string. The mud fluid returns to the surface through the tubing on which the liner is suspended. As pressure is nearly always encountered in this operation, the gravel-mud mixture is forced down the hole either continuously or in batches by means of lubricating chambers attached to the casing at the surface or is pumped down with special equipment mounted on a truck, the gravel itself not going through the pump.

There are several variations of the method used for gravel packing the liner by circulation after the pipe is in place but Fig. 1 indicates the general practice. The size of gravel grains and the other characteristics of the pack are the same as with the prepacked gravel liner, hereinafter described.

The prepacked liner is run into the well in lieu of conventional slotted, perforated, or screened pipe. It can be set opposite one or more productive zones and intermediate strata in multiple-zone completions can be cemented-off.

The general construction of prepacked liners is indicated in Fig. 2. There are several designs now available but all are based on the principle of confining a sheath of gravel around slotted pipe by a metal covering that provides free passage of the oil to the gravel. Sand flowing with the oil is entrapped by the gravel and when the proper size gravel is used for a particular formation sand, this entrapment will take place near the surface of the gravel and allow only a negligible amount of sand to permeate the inner interstices of the sheath. The

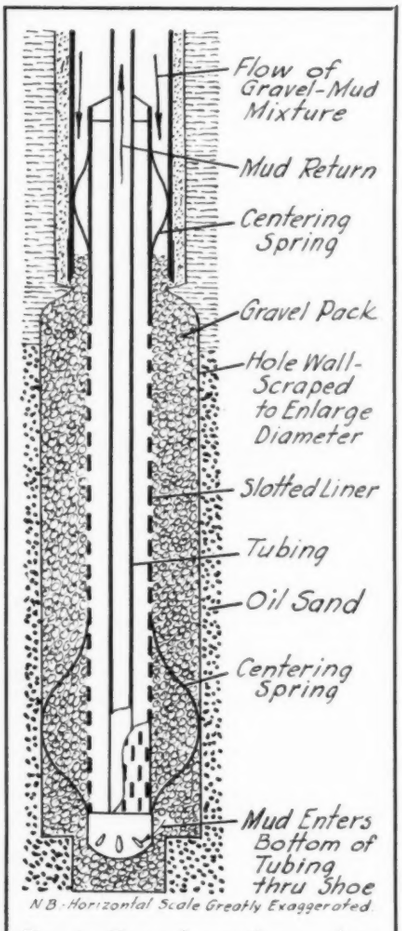

Fig. 1. General practice used to gravel-pack liner by circulation after pipe is in place

gravel pack is maintained at constant thickness to insure a uniform O.D. of the gravel-packed section.

The prepacked liner first to be developed was and is made with an outer covering of hand-woven, spring-steel wire mesh. Vertical metal spacers are placed at intervals of 8 in. to control the thickness of the gravel pack. The gravel sheath extends over the full length of a joint of slotted pipe except for a space at each end to allow making up joints with standard collars. The gravel is confined at the ends by steel rings welded to the liner.

The outer covering of another design is made of sheet steel, perforated with rectangular slots closely spaced in both directions and with the long side of the slots extending horizontally around the perimeter of the sheath. Spacer ribs are welded to the slotted liner and extend vertically throughout the length of the pack.

In a third design the outer covering is made of sheet steel perforated with round holes of a size just small enough to prevent the gravel from

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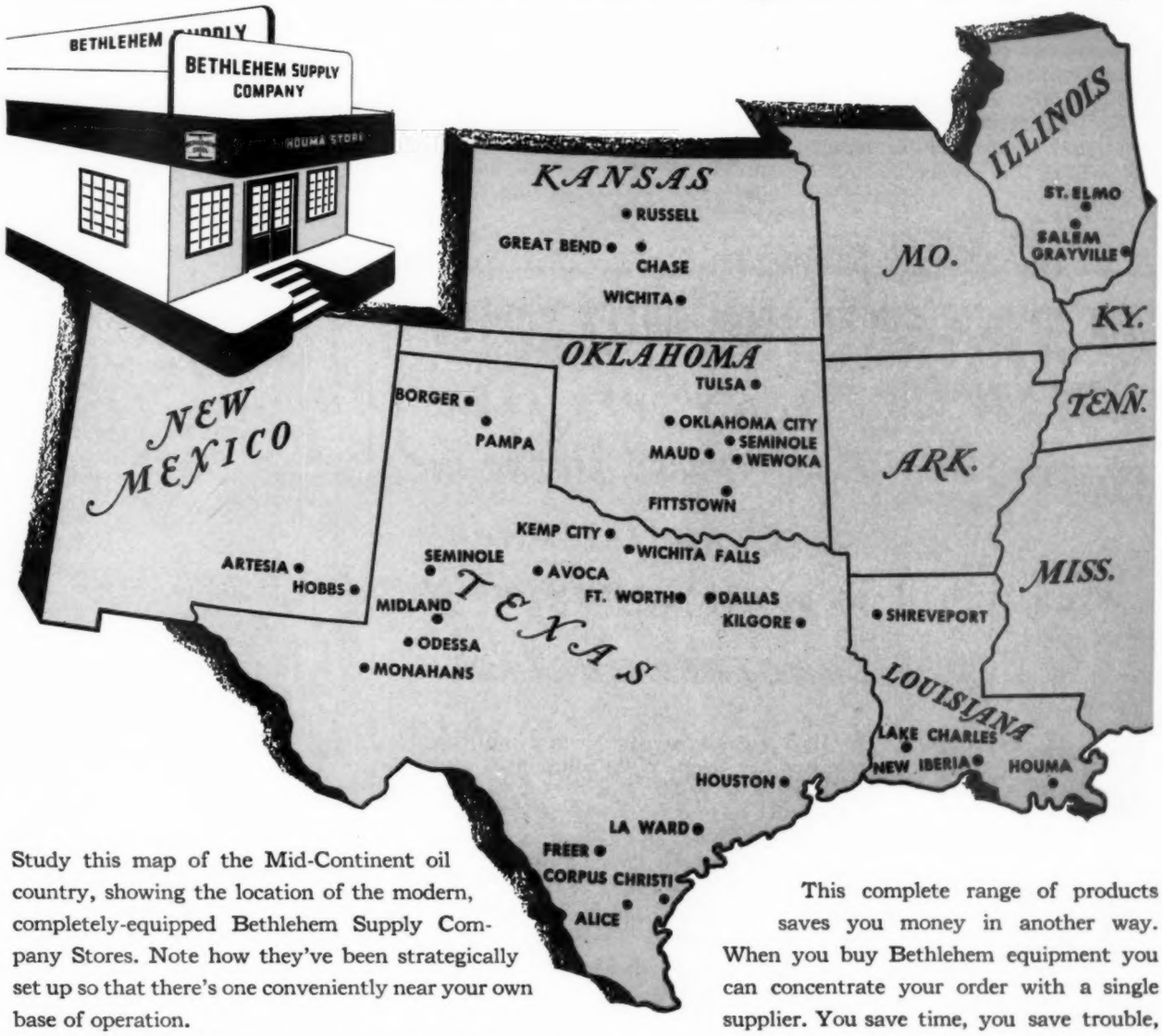

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passing. As in all types, the open area is fully adequate for flow of fluid.

A recently designed prepacked liner is made with a drillable-metal gravel retainer supplied with vertical slots. This type has drillable metal end collars that are not welded to the pipe but are attached by set screws. It is particularly adaptable to use on flush-joint liner, which is usually made of steel but may be of drillable metal. The purpose of the drillable metal outer covering is to provide for drilling-up with wash-over equipment if subsequent conditions make it desirable.

The first design developed is also being supplied in a sleeve type for use in areas distant from the manufacturing plant. This type is made in standard lengths of 4 and 8 ft. and in 2-ft. lengths for filling out on joints of pipe. The gravel is packed between an outer and inner covering and the prepacked section is slipped over slotted pipe at the well location. This permits the use of slotted pipe on hand and reduces the weight and size of shipment. When used on flush joint liner a special set of slip clamps is employed.

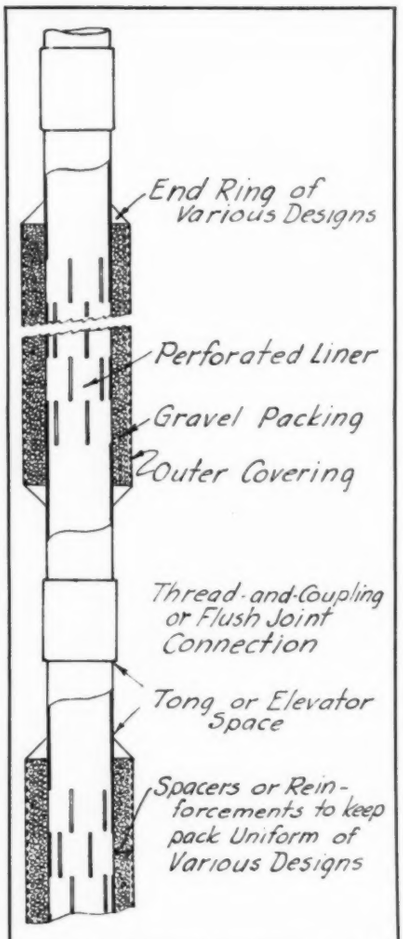
End Ring of Various Designs
Perforated Liner
Gravel Packing
Outer Covering
Thread-and-Coupling or Flush Joint Connection
Tong or Elevator Space
Spacers or Reinforcements to keep pack Uniform of Various Designs

Fig. 2. General construction of a pre-packed liner

The inside covering of the sleeve-type gravel pack is fabricated of either 14-ga. plate with 3/32-in. or 5/64-in. round holes or 7-mesh, 15-ga. screen; but the plate seems more suitable for the inside covering, which slides over the liner. The outer covering is usually 6-mesh, 14-ga. screen for the larger size gravel used or 7-mesh, 15-ga. for the smaller size.

Gravel size should be governed by the formation sand and it has been the practice either to analyze the available sand at the well or to send a sample to the manufacturer of the prepacked liner. In most cases the gravel used to date outside the United States has been from 0.110 in. to 0.131 in., although some has been from 0.093 in. to 0.110 in. Gravel of even smaller size has been employed in some of the California fields with the smallest reported as 0.075 to 0.093 in. All gravel used should have high strength, be acid-resistant, and be of proper size

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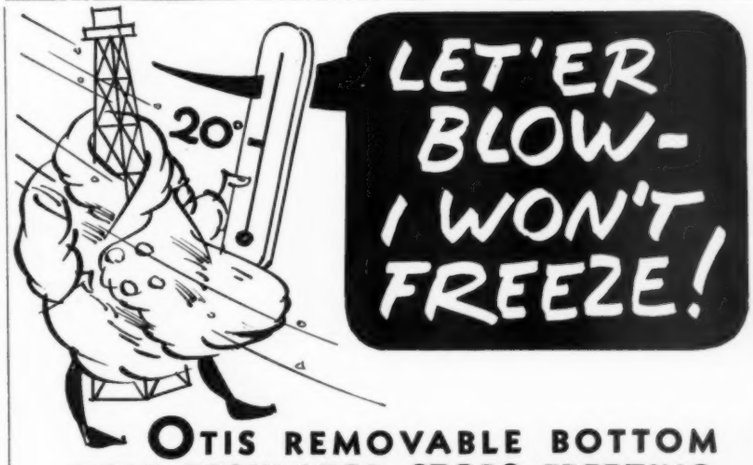
and shape.

The thickness of the gravel pack must not be less than a minimum determined by the gravel grain size that is, in turn, determined by the size of the sand grains of the formation. When using a pack made of 0.131-in. gravel the thickness should not be less than ¾ in. Actually, the average pack thickness used in the various designs is probably more nearly 1 in. The sleeve-type gravel pack as now being used on 6⅝-in. liner in some of the South American fields has a minus 8¼-in. O.D. when run through 9⅝-in. casing and a plus 8¼-in. O.D. for running through 10¾-in. casing. On 5½-in. liner the O.D. of the prepacked section is 7¼ in.

Although the greater number of cases where gravel packing has been used have been newly completed wells, there have been a number of repair jobs in which both prepacked liners and placed packs have been used. Some of the early gravel-pack jobs in Oklahoma were performed in wells that had been producing from open hole and in which large cavities had been created in the producing sand. The method followed in gravel packing these wells was to use direct circulation by pumping the gravel down through a string of tubing attached to the shoe of the liner. This shoe was equipped with a back-pressure valve and the operation was similar to a cementing job. The gravel in these jobs was mixed with oil. By using this method the gravel replaced the fluid in the cavities in an upward movement and prevented cavings from filling up the space. The method of placing the gravel by direct circulation has not been used recently but there are probably many conditions under which it might be employed to advantage.

The prepacked gravel liner has probably been used for repair work to a greater extent than the method of gravel packing in the hole. In several fields in California collapsed or worn liners have been pulled from wells making sand and replaced with prepacked liners. Each hole was wall-scraped to the necessary diameter and cleaned-out before the prepacked liner was run and no difficulty in getting the liner down such a prepared hole has been reported. There are probably many fields throughout the world where similar conditions prevail and where production could be increased and maintenance cost reduced by replacement of bad liner with prepacked gravel liners.

In some fields two or more productive zones are separated by water-bearing formations or by formations from which water is anticipated or that should be cemented-off for other reasons. When such zones produce sand and should be gravel packed, the prepacked liner offers a means of placing a gravel protection through each of the formations and yet provide for cementing between the different productive zones. The liner string is made-up with sections of prepacked gravel liners separated by blank pipe in the same manner as alternate sections of perforated and blank pipe are made-up in normal multiple-zone completions. The cementing is done by stages through cementing collars placed in the string at the bottom of the blank sections and the slurry is forced behind the blank pipe to whatever height is necessary. Protection against slurry reaching the gravel pack and the producing sand below the cement job is usually provided by cementing baskets. Similar protection to a gravel pack and sand above a cement job when there is danger of the slurry passing up too far behind the pipe is obtained by using inverted cementing baskets with ports below them to allow excess cement to return into the pipe.



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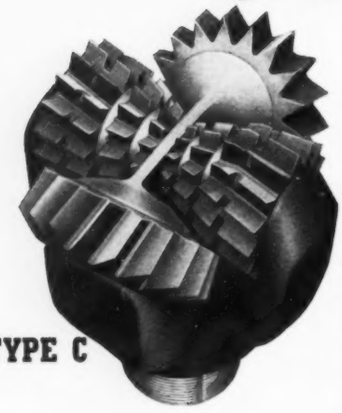

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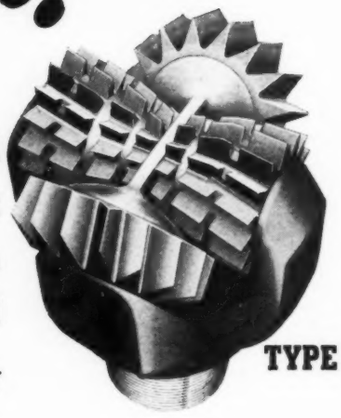

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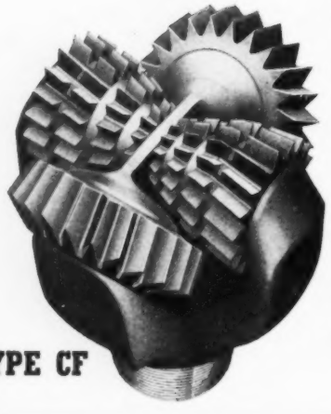

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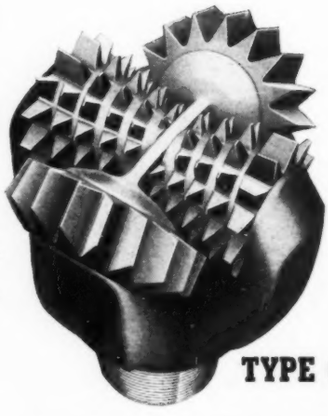

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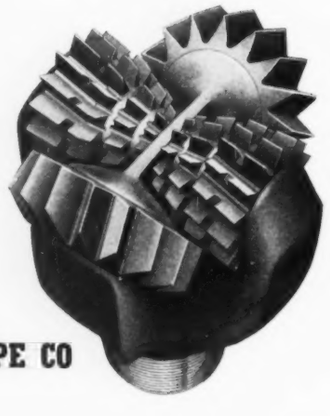

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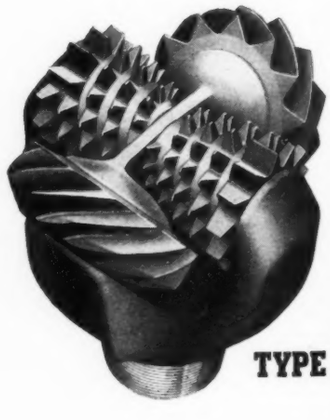

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Close Control of Verticality Reduces Drilling Time and Cost

A PETROLEUM ENGINEER EXCLUSIVE MONTHLY FEATURE

Major companies find it profitable to check direction of drilling at close intervals and thus forestall excessive deviation

By WALLACE A. SAWDON
Pacific Coast and Foreign Editor

IT is obvious that an oil well drilled through different formations with varying dips and degrees of hardness will not go on a vertical bee line from the surface to its position on the sand unless drilled under proper control. By proper control, however, the hole can be kept close to this bee line and be completed as a vertical well. This applies to wells of all depths. The economics of the vertical well not only include the drilling costs but also the operating expense throughout the life of the well. With these factors in mind some of the major operating companies have developed a more or less uniform method of controlled vertical drilling that has been found effective in completing wells in a number of fields in the United States with greater economy and speed.

Fastest drilling rates result from applying the proper weight on the bit at the proper rotating speed, other things being equal. One of the principal objectives of controlled vertical drilling is to obtain the use of the most efficient weight and speed over the greatest possible percentage of the total depth to which the hole is being drilled. This means the elimination of waste time and retarded drilling speed caused by having to bring a hole back to vertical or to within pre-established inclination limits when the bore is allowed to develop an excessive deviation.

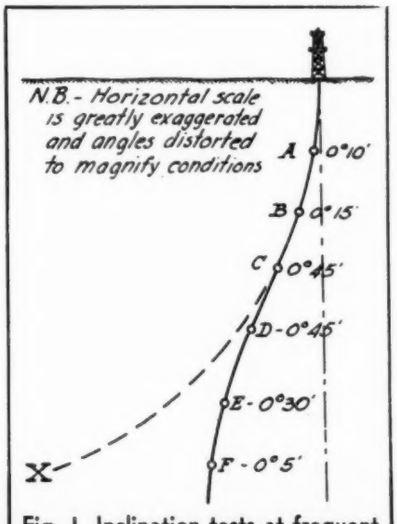
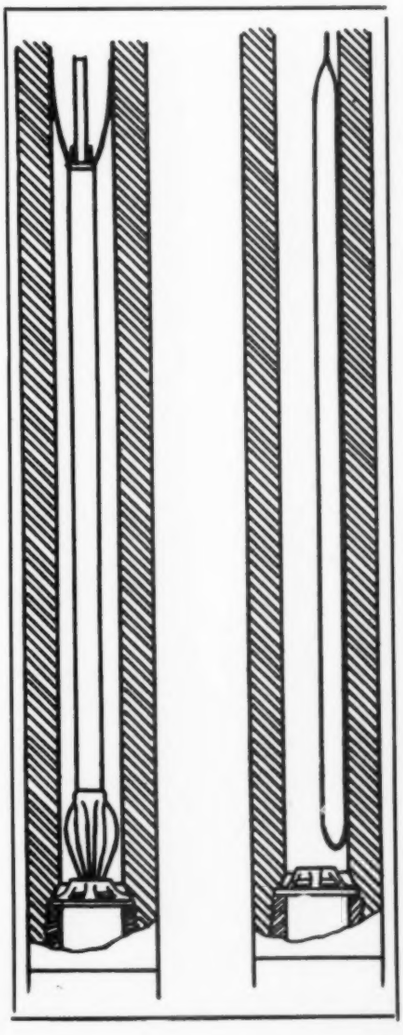


Fig. 1. Inclination tests at frequent intervals permit correction before deviations become severe

The control is accomplished by use of accurate instruments for indicating the weight carried on the bit, the speed of rotation, and the mud pump pressure; and by frequent, properly spaced, accurate checks of the inclination of the hole. The weight of the bit is concentrated as much as possible just above the bit so that the drill string will simulate a plumb bob with all or a large portion of the weight on the bit supplied by heavy drill collars and with virtually all the drill pipe kept in tension. The weight on the bit and the rotating speed are correlated to obtain the maximum hole-making efficiency. This efficient combination is most effective when the hole is vertical but fortunately is usually the combination that will be least likely to cause the hole to drift. Some operators during the last year or two have increased the rotating speed and reduced the weight with a resultant increase of hole-making speed and less tendency to deviate from the vertical.

Use of control methods is dictated by inclination readings taken at frequent intervals. The procedure being followed by several companies for close control is to run an inclination recorder capable of measuring small angles accurately whenever a length of drill pipe is added to the drill string. These readings are taken from the top of the hole to the productive zone. As pipe lengths will vary between 30 and 45 ft., the intervals between readings will also vary; but they are seldom more than 50 ft. apart. The instrument is run on wire line except when the drill string is about to be pulled out of the hole at which time the instrument may be dropped in as a "go-devil." In deep wells or in hard drilling where the bit will not make

Fig. 2 (left). The go-devil type recorder is usually self-centering within the drill collar. Fig. 3 (right). Recorders run-in on sand line rest against, and assume the inclination of, the drill-collar bore



Drilling a well 'neath the cocoanut palms is the South American way

more than 40 or 50 ft. the go-devil type alone can be used exclusively if desired.

The object of the small intervals between readings of inclination is to permit the hole to be straightened before the deviation from vertical becomes serious. In order to determine whether the angle of the hole is increasing, decreasing, or remaining the same, two or more readings must be compared as one record taken at a distance of several hundred feet from a previous record will not show the inclination trend of the hole with relation to what it may have been some distance above. If the closely spaced records show an increasing angle the weight and speed can be changed to reduce the angle while it is small.

The effectiveness of controlled vertical drilling depends on the use of small angles to indicate an inclinational trend and on immediate action taken to break this trend before the drift even closely approaches the maximum drift limit set in many drilling programs. This is indicated in Fig. 1, which is distorted to an extreme horizontal scale to illustrate the conditions more clearly.

At "A", which is some point less than 100 ft. from the surface, the inclination is found to be 10 min. and at "B" the angle has increased to 15 min. This increase is not sufficient to indicate a trend, so normal weight and speed are continued until the hole reaches "C" where a reading of 45 min. shows a definite inclination trend. The weight on the bit and the speed are then changed to break the trend and reduce the angle while it is still small. Otherwise the hole would continue to follow the trend toward "X" and would soon reach a large angle of deviation. Between "C" and "D" the hole is straight, but is not vertical, so further correction is necessary until "F" is reached. The trend here is toward the vertical so normal drilling weight and speed are employed. The need for several readings at short distances apart is evident, for the corrective action is based on the relationship between the successive readings and the trend they indicate.

In actual operations the return to vertical is usually very rapid unless the angle has been allowed to increase to as much as two or four degrees. The undercutting process must then be carried on for a greater distance with an accompanying delay in getting back to the use of the most efficient weight and speed. In true controlled vertical drilling as being practiced by a number of operators there is a critical angle that should not be

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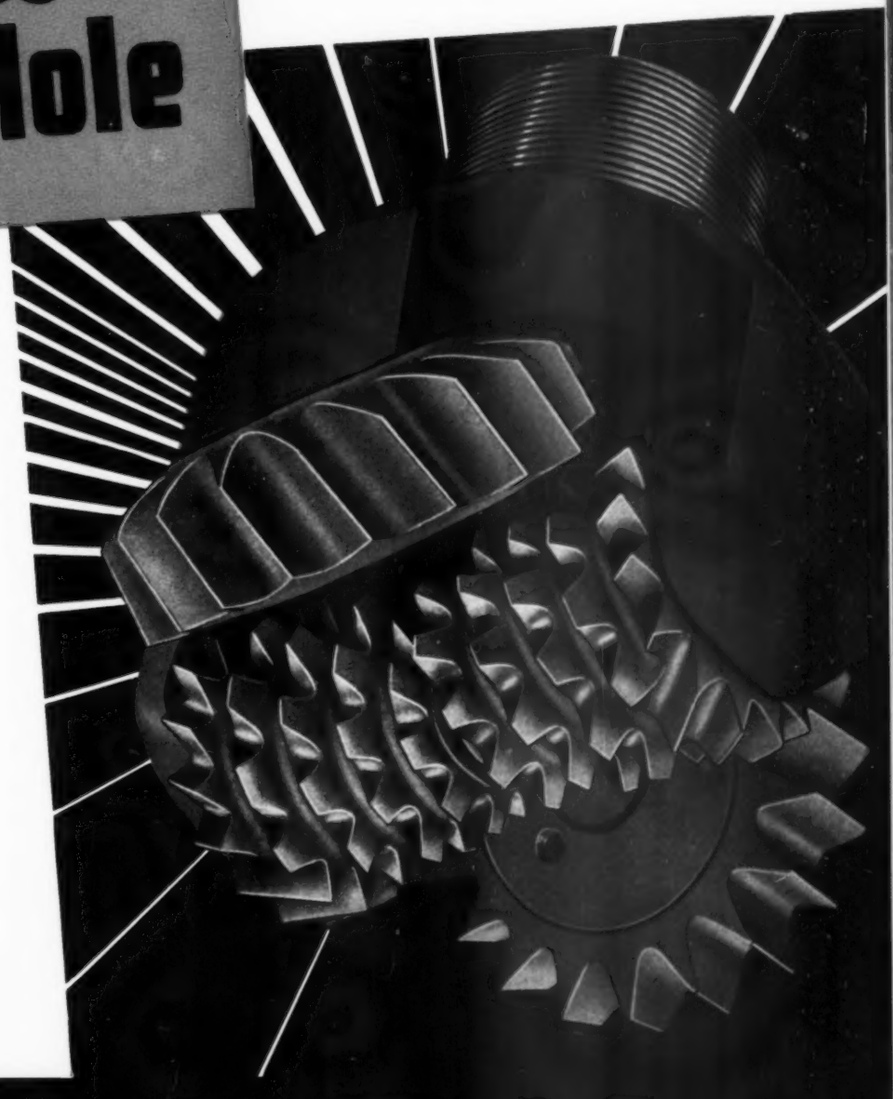
Triple Bearing (combination roller and ball bearings) gauge cutters prevent necessity of "reaming down" of hole to get on bottom.

Cross teeth on outside edge of cross cutters give maximum cross section of cutting surface preventing cross cutters from "rounding off."



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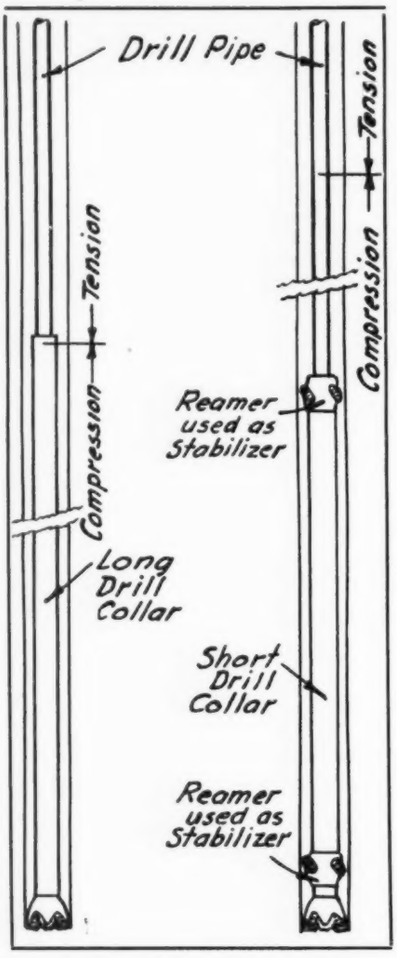


Fig. 4. Both of these arrangements are being used currently, either of which serves satisfactorily under certain conditions to provide ample weight on the bit without departing from vertical drilling

exceeded. This may vary from 45 min. to 1.5 deg., depending on the relative size of hole, drill collar and/or drill pipe; height of the center of gravity of the weight carried on the bit; size and position of reamers or stabilizers if any are used, and on other factors that may be present. This critical angle is never exceeded.

The accuracy of records taken to govern the control is obviously important. Instruments for measuring the inclination are available that are constructed with extremely accurate alignment of mechanism with the axis of the enclosing case. These instruments in the go-devil type of recorder are kept in alignment with the bore of the drill collar as shown in Fig. 2; and although the bore of the drill collar is not always as accurately aligned with its axis as it might be, the error is negligible and is frequently compensating with other factors. When the instrument is run in on sand line it lies along the side of the bore of the drill collar as indicated by Fig. 3.

When the drill collar itself touches or leans toward the side of the hole there will be a discrepancy in the reading that may be more or less than the actual inclination of the hole. This error usually will be small and as it will probably be constant in successive readings it will not materially affect the relative difference in the readings used as a basis for corrective measures.

Citing a deep well as an example of controlled vertical drilling, one such well that was drilled to a depth of nearly 13,000 ft. in California was completed with a maximum deviation of only 1 deg. 15 min. and with the final reading taken below 12,000 ft. recording zero. The maximum deviation permitted before the surface string was landed was 30 min. and in the remainder of the well the hole was brought back to vertical as soon as readings indicated an inclinational trend. It is believed that this well at this great depth was completed within the area directly below the derrick floor.

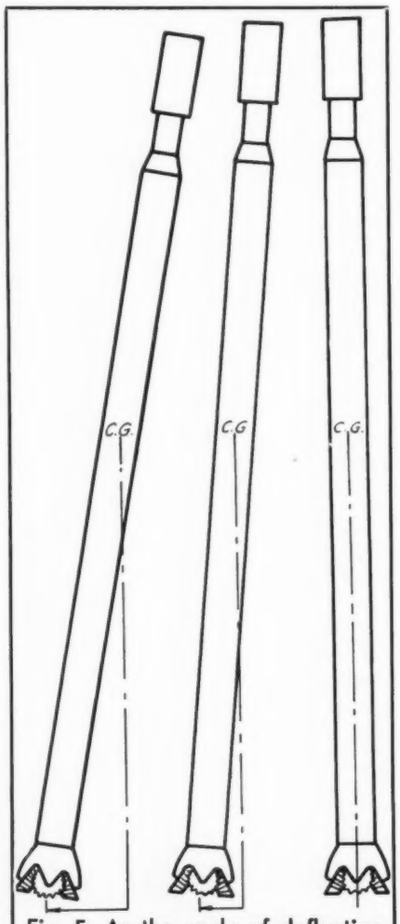


Fig. 5. As the angle of deflection increases, the amount of force exerted laterally becomes greater

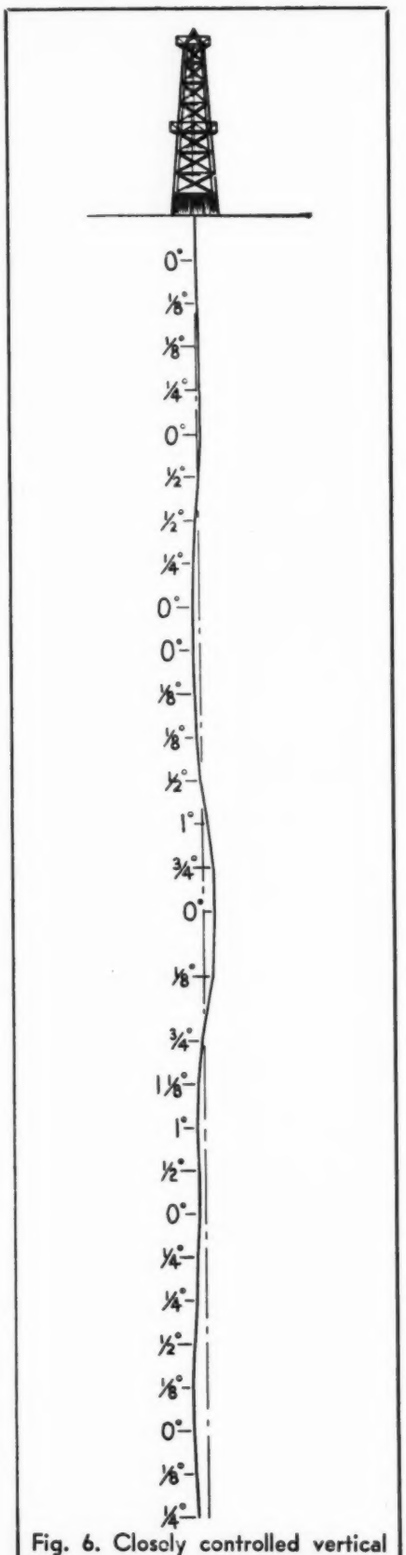
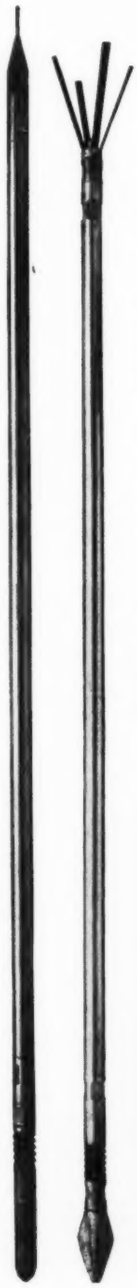


Fig. 6. Closely controlled vertical drilling need never depart materially from a straight line

It is vital that the surface hole be vertical for it is, in effect, the jig through which the remainder of the

CONTROLLED VERTICAL DRILLING

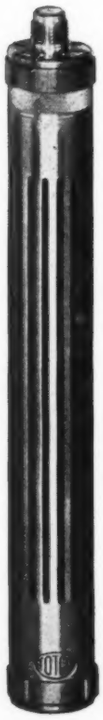
IS THIS



The Totco recording instrument (above right) is encased in a fluid tight go-devil while being run through the drill pipe. Two go-devils (A) for running on measuring line, and (B) for drop-in use, are shown.

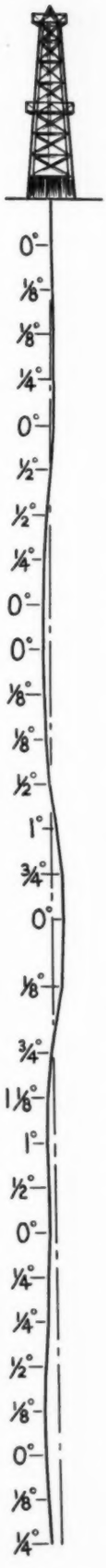
HERE is a chart of the course of a typical controlled vertical well. Note that the entire course of the well is within very close limits of a vertical line, and that the angles are low.

Controlled vertical drilling is the practice of USING the information supplied by accurate vertical angle records, taken at close intervals, to direct the course of the bit *straight down*. This results in greater drilling speed because, when the hole is vertical, every formation can be drilled with the most efficient combination of drilling weight and rotation speed for fastest penetration. Mechanical trouble and lost time are avoided; operating costs are reduced; the well is a better well during all of its producing life. It is the *modern* method of drilling—and any drilling crew can successfully practice controlled vertical drilling methods with the regular drilling equipment.

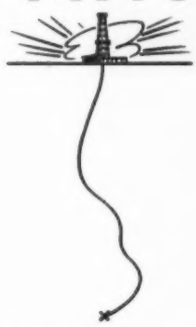


HOW INCLINATION RECORDS ARE USED TO CONFINE THE COURSE OF THE HOLE TO VERTICAL

A single record taken at any point and considered alone can only serve as a slope-test. In order to practise controlled vertical drilling the driller must be informed as to whether the angle of the hole is increasing, decreasing, or remaining the same. This information is gained by considering two or more records taken at close intervals (50 to 100 feet apart is recommended). If these records show an increasing angle, he immediately changes the drilling weight and speed to reduce the angle while it is small. The drill string acts as a plumb-bob, and tends to return to vertical when it is in tension; the bit, therefore, cuts away toward the *low* side of the hole when drilling weight is reduced, returning the hole toward vertical.



This is a controlled directional well. Readings of both vertical angles and direction are essential, and special drilling tools, deflecting equipment, and highly skilled supervision are required.



A crooked well costs more and requires more drilling time than a controlled vertical well. Slope-testing, the practice of taking vertical angle readings just to determine whether or not the contract limit is exceeded, is NOT controlled vertical drilling.

WHY YOU NEED THE TOTCO RECORDER FOR CONTROLLED VERTICAL DRILLING

To be fitted for use in controlled vertical drilling the recorder that supplies the angle readings of the hole must meet these requirements: The record must be ACCURATE, clearly readable to ⅛ of one degree or less, and available to the driller immediately; the instrument must be so designed and constructed that it can be easily and quickly handled by any member of the drilling crew with uniformly good results; timing must be so accurately controlled that records can be taken with a stop on bottom of not more than 45 seconds; the instrument must maintain laboratory accuracy indefinitely and have an operating efficiency of 98% or greater under all circumstances; the equipment must be easily adaptable for all methods of running. The Totco Recorder meets all these requirements; it was developed especially for controlled vertical drilling.

TOTCO

SEND FOR THIS FREE BOOK

Describes controlled vertical drilling methods, gives complete description of Totco Recorders, and illustrated operating instructions. Give Company name and position, please.

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hole will be drilled. If there is an inclination in the surface hole, excessive vibration and drill pipe and casing wear will occur as the tension of the drill string increases with depth.

In drilling this particular well all the weight carried on the bit was supplied by a 240-ft. drill collar so that at no time was the drill pipe in compression. Some operators have used even longer drill collars but the recent trend is toward shorter collars than were used a few years ago. A more recent development has been the use of reamers as stabilizers at the bottom and top of 60-ft. drill collars. More weight on the bit than can be supplied by the drill collar is necessary so some of the drill pipe above the collar has to make up the additional weight. Although the lower portion of the drill pipe is thus in compression, the drill collar itself is prevented from flexing to any appreciable extent by the stabilizers. Such a plan is believed to increase the plumb-bob effect even though the transition from tension to compression and the center of gravity are higher in the string. Both methods are illustrated in Fig. 4.

Considering the center of gravity of the weight carried on the bit, any slight inclination of the hole will place the vertical line through the center of gravity beyond the base of the slim mass providing the weight and will thus set up a lateral force at the point where the bit contacts the formation. (See Fig. 5.) The horizontal component increases as the angle of deflection increases and exerts a lateral force on the bit. This, together with the rotational position of the drill stem and the unstable position of the drill collar, causes the hole to depart from vertical at a constantly increasing rate. In addition, the weight applied loses some of its hole-making efficiency as a part of the weight is dissipated in horizontal force.

By rotational position of the drill stem is meant the position in the hole of that portion of the string that is in compression when excessive weight causes the pipe to lean toward the side of the hole or contact the wall. This deflection of the string will tend to cause the bit to cut at an angle. Long drill collars may bow or flex and that is why some operators favor the use of stabilizers below and above a comparatively short drill collar as it is believed that the rotational position of the pipe will then be near the center of the hole for a distance far enough above the bit to reduce deflection to a minimum under the weights necessary for most efficient drilling in some formations.

When a well is completed by controlled vertical drilling the angles are kept at such small values that they involve no appreciable horizontal deflection; and any deflections that do occur are usually offset by compensating deflections. In many cases some of the deflections are eradicated by the action of the drill string while rotating and when making trips in and out of the hole. The course of such a well is shown in Fig. 6.

The successful use of this method of drilling actually depends on frequently and accurately determining the effect of the weight carried on the bit so that any slight tendency of the hole to deviate can be halted while the angle of inclination is still very small. At these small angles the natural plumb bob tendency of the drill string can be utilized to straighten the hole by merely decreasing the weight to put more of the string in tension.

Liner sections are Easily and Quickly Welded together.

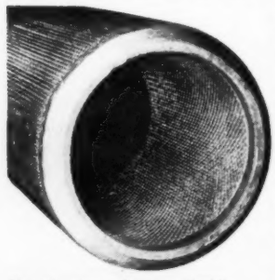
Nelson PRE-PACKED Gravel Liners

INCREASE WELL PRODUCTION AND PROLONG EQUIPMENT LIFE

The NELSON Gravel Liner for EXPORT has an Inner Screen next to the casing. This extra retaining member enables us to gravel-pack each NELSON Liner at the factory and ship direct to you in sections, ready for installation. This eliminates the usual transportation cost on pipe. NELSON Liners can be assembled at the well by simply slipping on perforated casing and welding. Proper gravel is furnished from your own sand analysis or ours, as you prefer. We maintain a modern laboratory for your benefit.

Sections of the NELSON Liner are slipped over your perforated casing. You can use new or used casing or reconditioned drill pipe that is suitable for the inner liner.

NELSON Pre-Packed Gravel Liners, especially designed and manufactured for EXPORT, have many advantages which save time and money in overseas' fields. NELSON Pre-Packed Gravel Liners Reduce Well Maintenance Costs, Eliminate Practically All Pulling and Bailing, Increase Production and make Equipment Last Longer. Many feet of this type are now being shipped to foreign fields. Illustrated literature on request.



Showing Inner Screen of NELSON Gravel Liner for Export.

NELSON PIONEERED THE PRE-PACKED GRAVEL LINER

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A PETROLEUM ENGINEER EXCLUSIVE FEATURE

This boulder-budging behemoth roots a path for the ditcher

New Line Adds to Gasoline Transportation Facilities in Mid-Continent Area

"Plow" for removing boulders ahead of ditchers and double-transmission cleaning machine among features of equipment employed in laying 186-mile line

By FRANK H. LOVE
Managing Editor

MAGNOLIA Petroleum Company has just completed the laying of a 4-in. gasoline pipe line between Fort Worth, Texas, and Oklahoma City, Oklahoma, a distance of 186 miles. Extending from the Magnolia Petroleum Company's refinery at Fort Worth to the Petty station three miles south of Oklahoma City, the line will transport various grades of gasoline, kerosine, and other distillates, terminals to be provided at Gainesville, Texas, Lone Grove, Oklahoma, and Oklahoma City for their distribution. The line follows a route via Denton and Gainesville, Texas, 10 miles west of Ardmore, Oklahoma, 10 miles west of Pauls Valley, 6 miles west of Purcell, 2 miles east of Norman, to Petty station.

In performing the construction work, the contractor, Williams Brothers Corporation, used two spreads, one on the Oklahoma end of the line, the other on the Texas section. Those working in Oklahoma made their headquarters in Norman for the initial stages of the work, later moving to Pauls Valley. The Texas crew first operated out of Gainesville, then from Fort Worth as the line neared that point.

Construction began August 12 and the Texas section of the line, consisting of 76 miles, was completed October 6. The Oklahoma section, 110 miles, was finished October 20.

Each spread had as its principal equipment a "plow" for removing boulders ahead of the ditchers concerning which more will be said later, two ditching machines, one cleaning and priming machine, one coating and wrapping machine, a bulldozer for backfilling, the necessary trucks for stringing pipe, tractors for lining-up

The firing line becomes mobile when electric welding is by the stove-pipe method

pipe, and welding machines. A total of 35 trucks and 20 tractors was used on the job. The Oklahoma spread used eight welding machines and the Texas crew seven.

Principal natural obstacles were numerous washes in Oklahoma, boulders and rock formations in both Texas and Oklahoma, and three river crossings. Early in the work it was found that large boulders and rock beds beneath the surface of the ground served to slow progress of the ditching machines, and although it was necessary to blast some of this rock, most of it could be removed by use of equipment popularly termed "the plow." This equipment was fashioned from two bulldozers and a specially-constructed large plow-type blade. The blade was fastened to the front bulldozer by a 1½-in. drawbar. Onto the back of the blade was welded two strips of angle iron. The blade of the rear bulldozer was set between these strips and could thus push the plow while the front bulldozer pulled it, at the same time by movement of the blade upward or downward regulating the depth of the plow. By thus clearing the way the ditchers were able to improve their speed and keep well ahead of the line-up and welding gangs, each machine making 2 to 4 miles per day depending upon terrain, cutting a trench 24 in. wide and 28 in. deep.

The three rivers crossed were the South Canadian near Norman, Oklahoma, the Washita near Pauls Valley, Oklahoma, and the Red River on the Oklahoma-Texas line. The South Canadian crossing was 1 mile in width, the Washita River crossing 400 ft., and the Red River crossing 1600 ft. The procedure in all cases was to make-up the pipe strings on the river bank and pull them into the river by means of tractors equipped with winch lines. The 4-in. pipe was encased in 6-in., being centered by lugs welded onto the pipe. A vent was cut in the outer pipe at specified intervals and hot Konite coating pumped into the annular space. When the coating material had set, this vent was closed by welding. River clamps weighing 600 lb. each were spaced approximately every 50 ft. The low water stage of the rivers made it possible to dig a trench by hand and give the pipe a covering varying from 18 in. to 48 in. as necessitated by local conditions.

The policy of encasing the 4-in. pipe with 6-in. and pumping coating into the annular space was also carried out in making highway and railroad crossings. The ends of the pipe were closed by casing bushings. The tunnel for the pipe was drilled with a manually-operated auger and each crossing vented.

On the whole the Oklahoma end of the line presented the most difficulty due to the many washes, which impeded progress of the ditching equipment and required the making of numerous sag bends. Because of the small diameter of the pipe all pipe bends were made cold.

The line pipe was shipped by rail to points convenient to the work, and accessibility of the right-of-way made stringing easily accomplished. The pipe was received in random lengths, measuring 46 to 50 ft. The ends of each joint of pipe were covered by metal cap-type pipe protectors to prevent entrance of foreign matter to the interior, which were not removed until the welders were ready to make the tack welds.

The stove-pipe method of welding was employed for the entire line, two electric welding machines being used by each crew for the tack welds and 5 to 6 for the finish welds. Three beads were run on each joint, each welder making between 50 to 60 welds per 9-hour day.

After the pipe was welded and left on skids above the ditch it was cleaned and primed by a traveling-type machine. A feature of this machine was its double transmission that made it possible to regulate independently the traveling speed of the machine and the rotating speed of the cleaning head. In other words, when it became necessary to slow-down the travel of the machine

Left: Two to four miles of trench per day is a steady diet for this ditcher

Below: Coating and wrapping the line pipe in one operation

IDEAL Consolidated Rig...

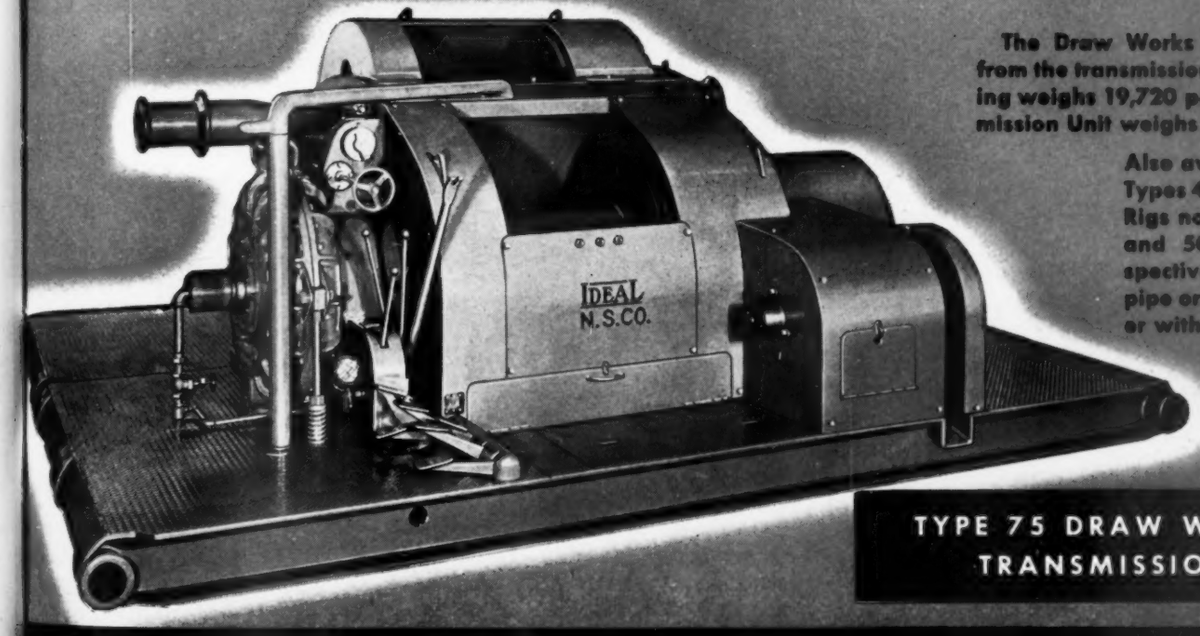
"Reg. U. S. Pat. Off."

Rated Drilling Capacity
7500 feet with 4½"
Drill Pipe

NEW TYPE 75

The Ideal Type 75 Consolidated Rig includes a complete internal combustion engine powered drilling rig, consisting of the Type 75 Draw Works and Transmission Unit with Master Friction Clutch and Gear Reverse, Slush Pump, Transmission Equipment and two Engines having a maximum combined output of 500 H. P., for drilling operations to 7500 feet with 4½-inch drill pipe and proportionately deeper with smaller drill pipe.

The Ideal Type 75 Draw Works has a selection of six hoisting speeds and three rotary drive speeds and consists of two units, one—the hoisting drum assembly, and two—a complete oil bath heavy-duty transmission unit with three forward speeds and gear reverse, including Master Clutch Shaft and jack shaft. These two units, when bolted together, provide a compact arrangement, and when disconnected offer increased portability.



The Draw Works Unit when separated from the transmission portion for transporting weighs 19,720 pounds while the Transmission Unit weighs 15,850 pounds.

Also available are our lighter Types 40 and 50 Consolidated Rigs nominally rated at 4000 and 5000 feet capacity respectively with 4½-inch drill pipe or proportionately deeper with smaller drill pipe.

TYPE 75 DRAW WORKS AND TRANSMISSION UNIT

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A bulldozer backfilling the finished product

the revolving speed could be maintained or increased if desired. This feature also would be of particular value in instances of pipe-line reconditioning, as it would be possible to retard the speed of travel and increase the speed of the cleaning head when badly corroded sections of line were encountered. In the past it quite often has been necessary to reverse the direction of the machine and "workover" a section of pipe several times before it was adquately cleaned.

Hot coating and asbestos felt and kraft paper wrappers were applied to the pipe over the entire length of the line. The now standard machine that performs all three of these functions in a single operation was employed for this work. An accompanying illustration shows this machine in operation. This unit, propelled by a gasoline engine, rides the pipe as the latter is held above the trench by a tractor equipped with boom and winch. A hopper receives the hot coating, which flows over the pipe through a regulating valve, the overflow being caught by a drip pan and pumped back into the hopper. The gasoline engine that propels the machine also drives the pump that forces the overflow from the drip pan back into the hopper, as well as powering the wrapping arm. The coating adheres to the pipe to a thickness of approximately 3/32 in. and application of the asbestos felt and kraft paper wrappers follows immediately.

The pipe was lowered as soon as coated, except that a skid was left about every 300 ft. and this pipe lowered in the cool of the morning when fully contracted. Backfilling was performed by use of bulldozers.

Although not erected as yet, terminals are to be constructed near Gainesville, Texas, Lone Grove, Oklahoma, and Oklahoma City, Oklahoma. Facilities will be provided for storage and for truck- and tank-car loading of gasoline, kerosine, light oils, and other distillates, which will vary according to the consumer demands in different areas.

Ben Law was the general superintendent for Williams Brothers Corporation, and spread foremen were Leeman Creech in Texas and W. H. Law in Oklahoma. George Jackson was chief inspector for the Magnolia Pipe Line Company.

P 425.218.2

Offset Flume for Mud Sampling

By
CHAS. C. LYNDE

SAMPLES taken from the mud stream are overloaded with cuttings if drawn from the bottom of the flow, and the outlet tends to clog quickly if closed-off or pinched-down; whereas if the outlet is at the top, no sample is obtained unless a full stream of mud is maintained.

By welding a short 2-in. nipple into the side of the 6-in. pipe serving in lieu of the usual open flume mud return, one drilling company automatically obtained a representative or mid-sample, controlling the amount of efflux through the branch by means of a gate valve situated close to the main pipe.

The stream from this branch, led into a flume with a number of cross members to permit the placing of baffles to allow cuttings to settle-out and accumulate, makes the obtaining of a sample simply the task of opening the gate for a short period, flushing out the residue from previous samplings, and then setting the baffles and allowing any desired small percentage of the fresh mud stream to flow through the bypass until the desired sample has collected.

A representative sample of mud is directed into the flume through a 2-in. pipe welded into the 6-in. mud return line

The lower end of the bypass flume is connected to the mud pits, so that no mud is lost through the use of the device.

"...actually saved me almost $500 per string!"

—That is what E. C. Johnston, oil producer and drilling contractor of Longview, Texas, says about Smith Casing. His letter is reproduced verbatim below. . . .

"In response to your recent inquiry, this is to advise that I have set my fifth A. O. Smith oil string at Tinsley, Mississippi in that state's first oil field.

"On 5½" O. D. casing, I was able to go from 17# H-40 to your 14# High Yield and substantially increase my safety factors against collapse and pull-out. This change actually saved me almost $500 per string.

"My field men like the longer lengths of Smith Casing, as this contributes much to shorter running time without sacrificing any safety measures.

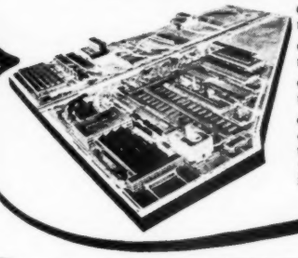
"I would like to express my appreciation of your splendid co-operation in matters pertaining to our business relationship."

Yours very truly,

E. C. Johnston

DID YOU KNOW?

- A. O. Smith Corporation, major supplier of casing, also produces . . .
- A large portion of the line pipe for transporting petroleum products . . .
- Most of the pressure vessels for refining them . . .
- Most of the frames for the automobiles that use them. . . .
- The economic welfare of the entire petroleum industry and that of A. O. Smith Corporation with its 5000 employees are inseparably interlocked.



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You Too Can Save Up to $1000 or More on Each Well

If you are interested in saving up to $1000 or more—with *safety*—on each well, send the figures for your next string to the nearest A. O. Smith office. A. O. Smith Corporation, Milwaukee, Wisconsin. Offices at: New York, Pittsburgh, Chicago, Tulsa, Dallas, Shreveport, Houston, Corpus Christi, Midland, Los Angeles.

A. O. SMITH CORPORATION

Milwaukee, Wisconsin

MANUFACTURERS OF ELECTRIC-WELDED

Casing

Pressure Vessels • Line Pipe

Pressure Distribution About a Slotted Liner in a Producing Oil Well[1]

Part 2

By FRANK G. MILLER

Assistant Petroleum Engineer, U. S. Bureau of Mines, Petroleum and Natural Gas Division, San Francisco, California

A photograph and biographical sketch of the writer can be found on page 109 of the September issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

AFTER the permeability data had been collected the pressure losses in the vicinity of a slot were measured for various rates of flow. The low-pressure limb of a differential manometer was connected to a tap in the well slightly downstream from the slot (see Fig. 3) and the high-pressure limb was connected to tap 7 slightly upstream from the slot and in the sand; $\frac{r_7}{r_w} = 2.25$, where r_w is the well radius. A pressure differential, thus measured, would be caused by the flow resistance between tap 7 and the well wall plus the slot resistance. This head loss is plotted as a function of flow rate in Fig. 7 for all slots tested.

The slot loss, alone, for various rates of water flow, was obtained with the same manometer connection but with the apparatus emptied and cleaned of all traces of sand. Fig. 8 is a graphical representation of these data for all slots tested.

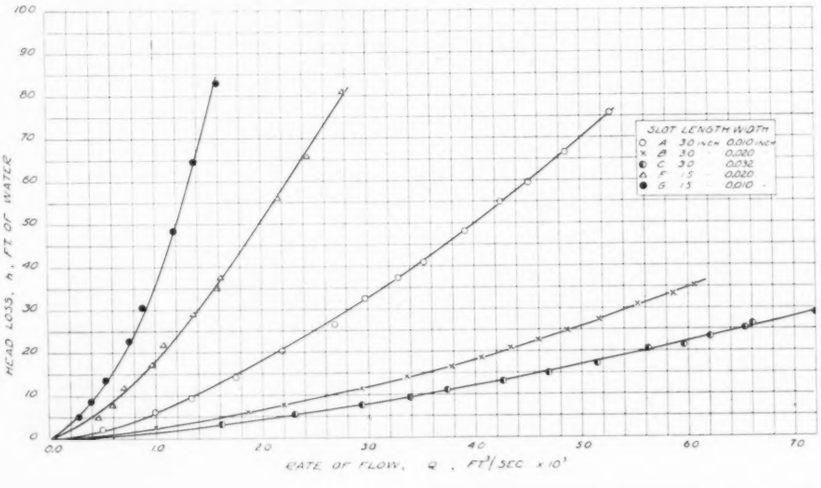
A comparison of Figs. 7 and 8 shows that a slot loss is small as compared to the corresponding loss due to the slot plus the sand out to $\frac{r_n}{r_w} = 2.25$. If Darcy's law described the flow in the sand near the well wall, therefore, the curves of Fig. 7 would approach straight lines. The loss of head, not being directly proportional to the first power of the flow rate but to some power greater than 1, suggests turbulence. The curves of Fig. 8 were subtracted, graphically, from those of Fig. 7, so that a third set of curves could be drawn, in which the pressure drop across the sand, between the well wall and $r_n = 2.25\ r_w$, could be plotted against the flow rate—one curve corresponding to each slot. This procedure is not strictly correct, as the approach conditions of any slot will be changed somewhat by the presence of sand, but as the slot loss is small compared to the loss due to the sand, no serious error is introduced. The results obtained in the foregoing manner when plotted on logarithmic paper are shown in Fig. 9. The curves, as shown, are straight lines for a range of flow rates between 0.6×10^{-3} and 1.8×10^{-3} cu. ft. per sec. This upper limit of the range of flow rates is specified particularly, as experimental data corresponding to all slots are not available for faster rates.

In interpreting the foregoing results it should be realized that the experimental flow rates were high because the thickness of the sand was only 3 in. and the well diameter 1 in., and only the sand of a 45-deg. sector was drained; actual well production rates per 3 in. of sand per 45-deg. sector would be lower. Furthermore, corresponding fluid velocity in the sand near the well wall would be less due to the much larger diameter of actual wells. Hence, it is not likely that turbulent flow occurs in the sand near the wall of an actual well producing a single-phase liquid in the tubing. It will be significant to point out that there was no turbulent flow in the sand beyond tap 7 in any of the experiments, as repeated determinations of $\left(\frac{P_n - P_7}{Q}\right)$ for any particular test checked regardless of the flow rate used, whereas if any turbulence had been present the ratio would have varied with the rate.

It will now be apparent that the results illustrated in Figs. 6 and 9 may be combined and replotted to show the pressure distribution in the sand from the well wall outward for any particular flow rate or slot on which data are available. Figs. 10 and 11 illustrate the results plotted in this manner for the maximum flow rate on which data on all slots were collected and for one lower rate. The curves of Figs. 10 and 11 are compatible with those of Fig. 6, in that each curve represents the best straight line through the respective points for the five greatest values of $\left(\frac{r_n}{r_w}\right)$.

The intercept on the pressure axis when one of these curves is extrapolated indicates the pressure loss, for the particular flow rate, due to all additional flow restrictions occurring in the sand beyond the well wall. It would not be strictly correct to compare directly the intercepts (corresponding to one flow rate) and find

Fig. 7. Head loss, due to slots plus sand between liner wall and $r_n = 2.25r_w$, as a function of flow rate



[1]Part of a more detailed thesis submitted to the University of California in partial fulfillment of the requirements for the degree of master of science in mechanical engineering. This paper also appeared as T.P. No. 1222 in A.I.M.E. *Petroleum Technology*, August, 1940.

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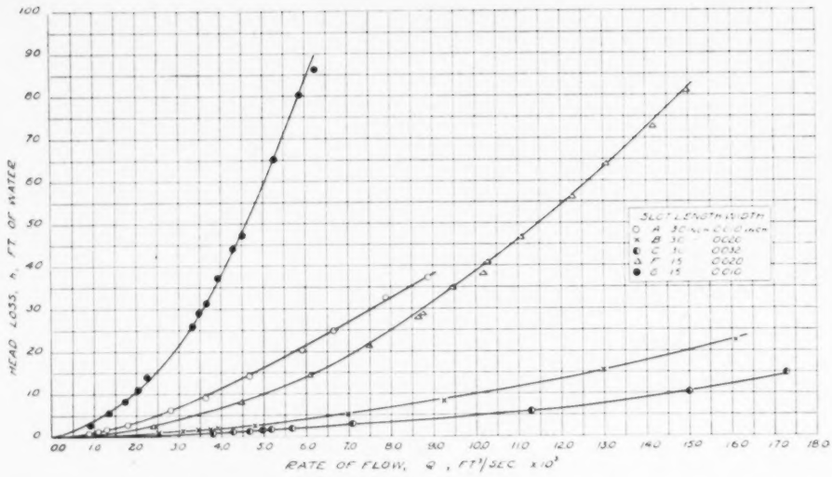


Fig. 8. Head loss, due to slots alone, as a function of flow rate—no sand present

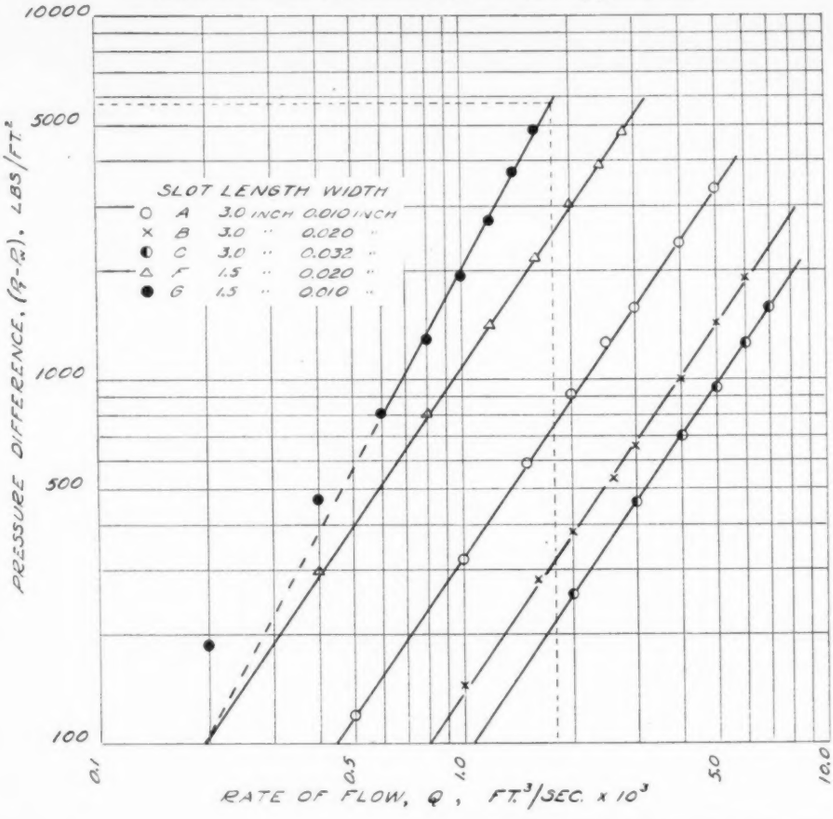
the effect of slot dimensions as the viscosity of the water and the average permeability of the sand differed from test to test. The results of the electrical analogy experiments will be used, however, to compute the pressure loss (intercept value) that would have resulted had convergence of the streamlines been the only influencing factor. The magnitude of the ratio of the experimental loss, obtained from the fluid flow experiments, to the theoretical convergence loss, computed from the results of the electrical analogy experiments, affords a measure of the effect of bridging and arching as related to slot size.

Electrolytic conduction model experiments. Six copper strips, analogous to slots in a liner, were tested in the electrical analogy apparatus. Three of the strips were for two-dimensional flow; that is, each of these was exposed to the entire height of the electrolyte when being tested so that the distribution of the current lines would be identical throughout the electrolyte in all horizontal planes parallel to its surface. The depth of the electrolyte was 3 in. in all experiments, therefore the length of the strips for the two-dimensional flow was 3 in. The width of the strips, designated as strips A, B, and C, was 0.020, 0.040, and 0.064 in., respectively. The "well" diameter was 2 in., so that the ratios of the width of strips A, B, and C to the "well" diameter were 0.010, 0.020, and 0.032, respectively. The other three strips, G, F, and D, also, were 0.020, 0.040, and 0.064 in. wide, respectively, but only 1½ in. of their length could be exposed to the 3 in. of electrolyte when each was tested. The portion of a strip exposed to the electrolyte in each test extended from the surface to a point 1½ in. below the surface, hence three-dimensional flow resulted as the current lines in the vicinity of the strip had to converge in vertical planes as well as horizontal planes to pass into the strip.

In the description of the fluid flow apparatus it was stated that the diameter of the well was 1 in., that the sand of a 45-deg. sector was drained in the tests of each slot, and that the thickness of the sand was 3 in. In the electrolytic conduction model the diameter of the "well" was 2 in., and a 45-deg. sector of the conducting medium was opposite the face of the well in each test, but the depth of the electrolyte was made only 3 in. for convenience in performing the experiments. If the model were geometrically similar to the sand apparatus the depth of the electrolyte necessarily would be 6 in. If an imaginary horizontal plane were passed through the center of the sand in the prototype, however, then the model as constructed would be geometrically similar to a half of the fluid-flow apparatus, taken either above or below that plane. Furthermore, voltage differences actually measured in experiments with the model were exactly double what they would have been if the depth of the electrolyte had been 6 in. instead of 3 in., if the strips for two-dimensional flow were considered to be 6 in. long instead of 3 in., and if the strips for three-dimensional flow were taken to be 3 in. long, with a blank space on the face of the well opposite the electrolyte for 1½ in. at each end of the strip. Computations and results on the model experiments, therefore, were based upon a 6-in. depth of electrolyte so that a direct comparison could be made with the fluid flow experiments.

Fig. 12 is a graphic representation of the results computed from the data taken on the electrolytic conduction

Fig. 9. Pressure differential, due to sand between liner wall and $r_n = 2.25r_w$, as a function of flow rate with different slots opposite sand


PRESSURE DIFFERENCE, (p-p), LBS/FT²
RATE OF FLOW, Q, FT.³/SEC. x 10³
SLOT LENGTH WIDTH
A 3.0 INCH 0.010 INCH
B 3.0 " 0.020 "
C 3.0 " 0.032 "
F 1.5 " 0.020 "
G 1.5 " 0.010 "

● In the work-a-day world most activity ceases by sunset. Men and machinery quit their tasks, and night is reserved for rest.

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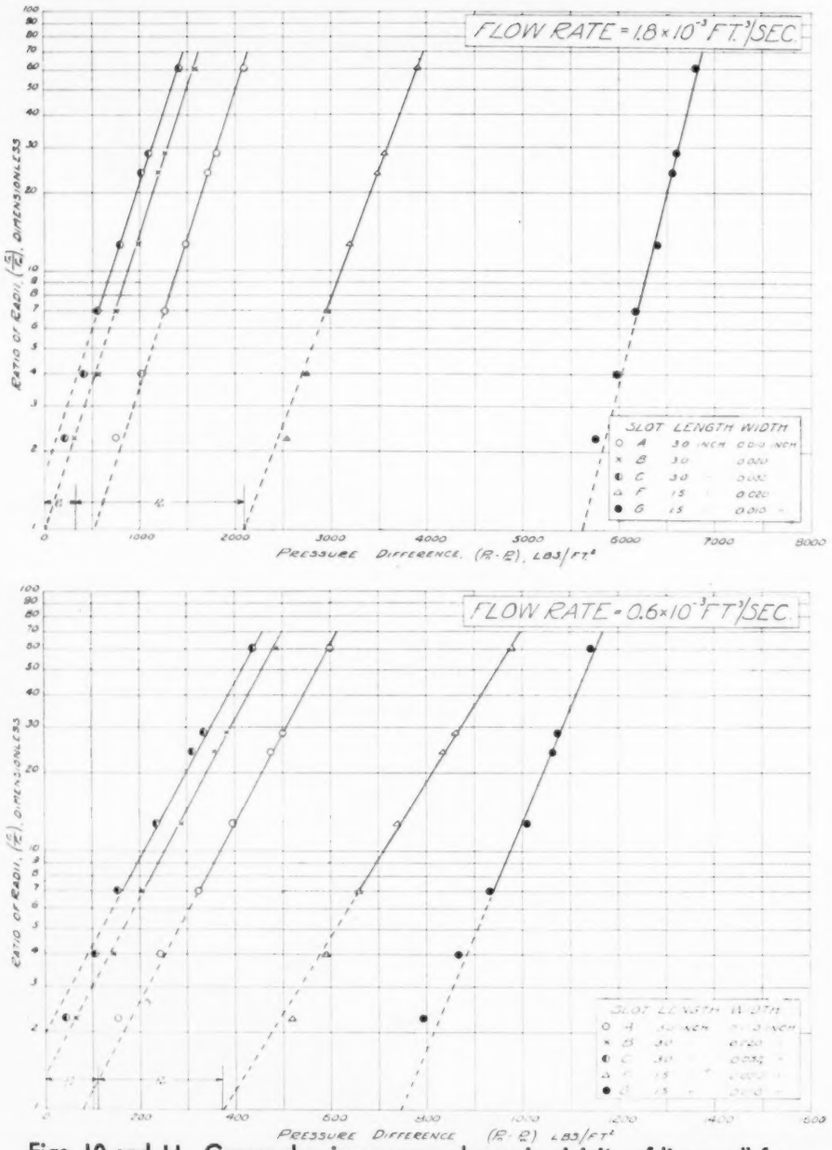
FLOW RATE = 1.8 × 10⁻³ FT.³/SEC.
RATIO OF RADII (r_n/r_w), DIMENSIONLESS
PRESSURE DIFFERENCE, (R-E), LBS/FT.²
SLOT LENGTH WIDTH
A 30 INCH 0.010 INCH
B 30 0.005
C 30 0.002
F 15 0.020
G 15 0.010
FLOW RATE = 0.6 × 10⁻³ FT.³/SEC.
RATIO OF RADII (r_n/r_w), DIMENSIONLESS
PRESSURE DIFFERENCE (R-E) LBS/FT.²

Figs. 10 and 11. Curves showing pressure losses in vicinity of liner wall for different slots and two rates of flow

model. The distribution of voltage through the electrolyte in the tank was determined for various rates of current flow for each strip. The six different curves in the figure are for the six copper strips (analogous to slots) tested. The heavy lines represent the radial part of the flow pertaining to the various strips. The dotted parts of the lines are extrapolations into the nonradial flow region.

Equation (1) describes the radial flow of a fluid through a porous medium. The corresponding equation for the flow of current through an electrolyte in a tank having the shape of a 45-deg. radial sector would be:

$$\log \frac{r_n}{r_w} = \frac{\pi h}{(2.303)\, 4\, \sigma} \left(\frac{E_n - E_w}{I}\right) = c \left(\frac{E_n - E_w}{I}\right) \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where $(E_n - E_w)$ is the voltage drop between a point at the "well' radius, r_w, and some point a distance r_n from the "well" axis, I the current flowing (amperes), σ the specific resistance of the electrolyte (ohm-ft.), h the depth of the electrolyte in the tank (ft.), 2.303 the factor for converting common logarithms to natural (Napierian) logarithms, and c a constant.

Inspection of the figure will show that the equations of all the curves have the general form:

$$\log \frac{r_n}{r_w} = c\left(\frac{E_n - E_w}{I}\right) + b, \quad . \quad (6)$$

where b is the intercept cut off on the $\left(\frac{r_n}{r_w}\right)$ axis. It will be apparent that $-\left(\frac{b}{c}\right)$ is the intercept cut off on the $\left(\frac{E_n - E_w}{I}\right)$ axis.

A study of the flow system reveals that these curves when extrapolated to the $\left(\frac{E_n - E_w}{I}\right)$ axis establish intercepts in each instance that represent graphical measures of the added voltage difference, for a unit rate of current flow, required to overcome the additional resistance due to convergence of the lines of current in passing into a strip.

The parallelism of the curves in Fig. 12 indicates that the specific resistance of the salt solution was the same in all experiments, so that direct comparison could be made among the test results for the strips. The value of the specific resistance may be computed from the slope determined from any one of the curves as from equation (5):

$$\sigma = \frac{\pi h}{4(2.303)c} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

The specific resistance was found to be 6.88 ohm-ft. or 210 ohm-cm. The specific conductance $\frac{1}{\sigma}$ would be 0.0047 mho per cm., according to the experimental results.

Tabular data[6] are available in which equivalent conductivities of sodium chloride (NaCl) solutions are given in terms of their concentrations. The specific conductance obtained from the results of the experiments was compared with that computed from the tabular data after the concentration of the test salt solution was found, and the two values agreed. The concentration of the test salt solution was determined by titrating it against a standard silver nitrate ($AgNO_3$) solution.

The experimental curves are used for a comparison on the basis of strip dimensions and on the relative effect of two- and three-dimensional flow for a conducting medium homogeneous to the well wall. For this purpose the values of the intercepts on the $\left(\frac{E_n - E_w}{I}\right)$ axis, representing the added voltage drop per unit rate of current flow due to convergence, are used. Hereafter in this report such intercept values are termed convergence losses. The intercept for strip C, designated as $\left(\frac{\Delta E}{I}\right)_C$ in the lower left corner of the graph, represents the convergence loss for this particular strip. If the convergence loss were zero the flow would be radial

[6] *Chemical Engineer's Handbook*, by J. H. Perry. First edition, McGraw-Hill Book Company, Inc., New York, New York, 1934, p. 2310.

(Continued on Page 142)

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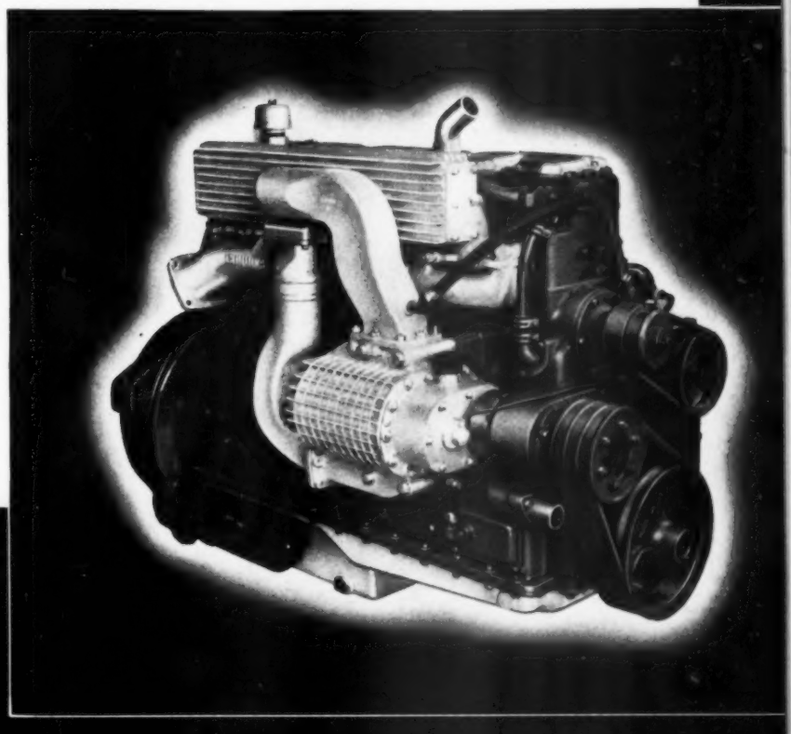
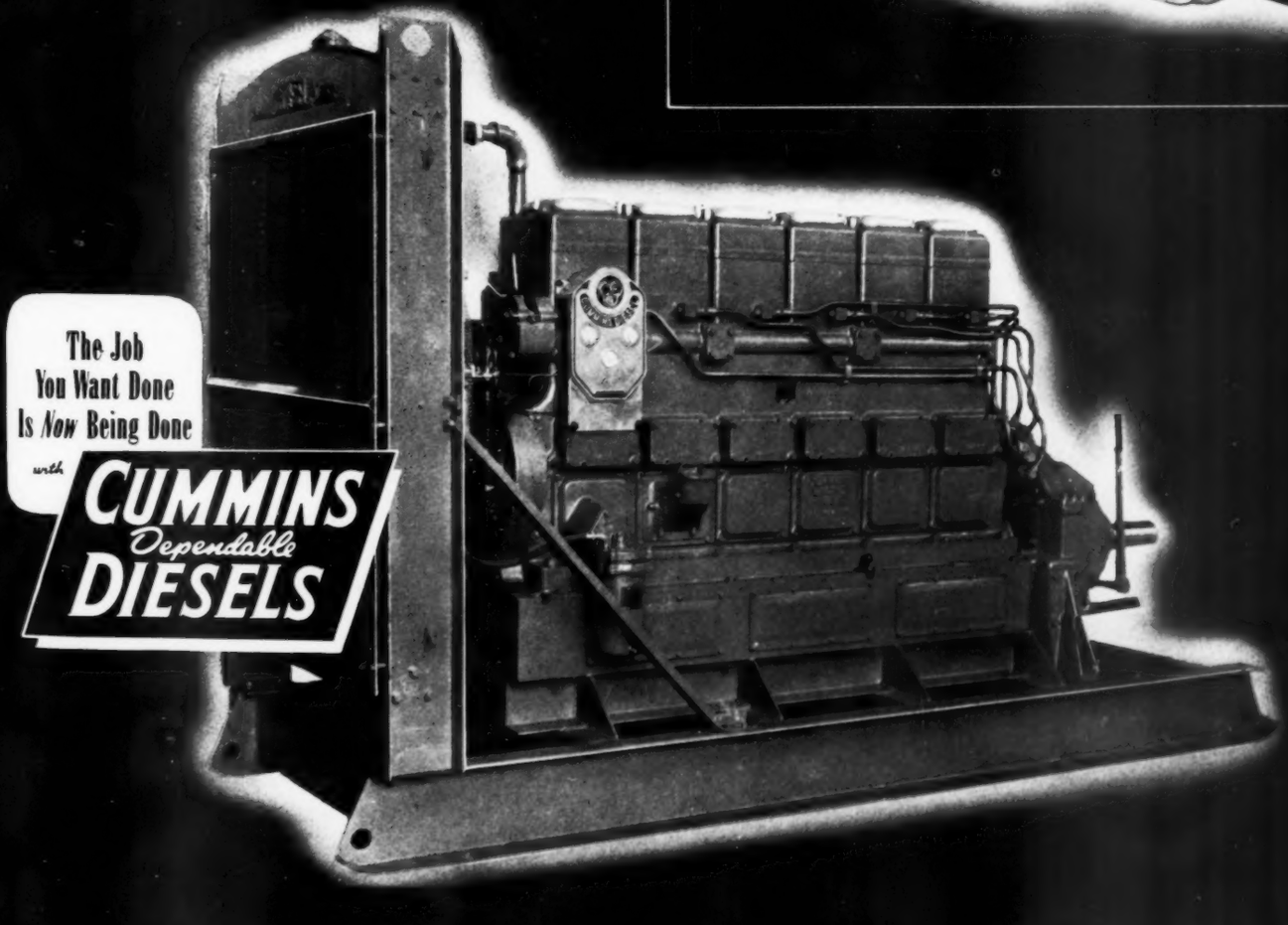


BELOW: *Model LP-600 Cummins Dependable Diesel, 250 hp. at 1,000 rpm.*

RIGHT: *Model HBIS-600 (Supercharged) Cummins Dependable Diesel, 200 hp. at 1,800 rpm.*



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The Petroleum Engineer, in accepting this award, fully acknowledges the unstinted cooperation of the scores of influential men in the petroleum industry whose assistance made possible our efforts toward industrial peace and mutual understanding. We share the honor of the award with them.

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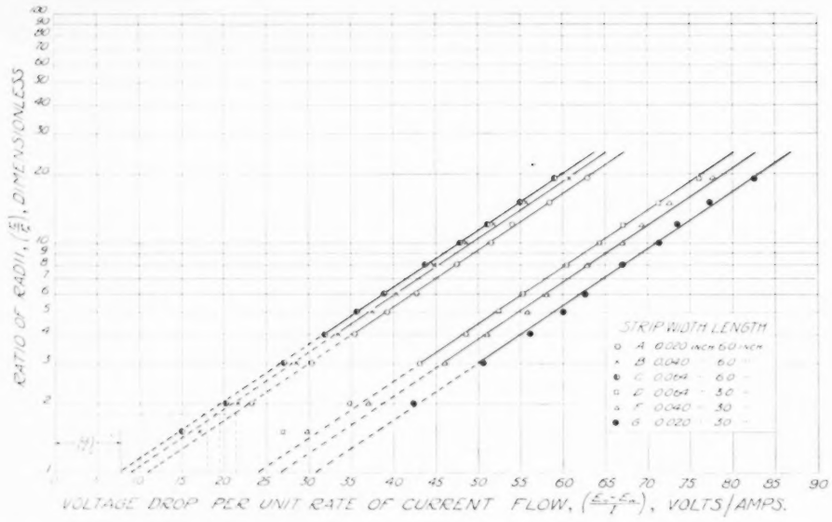

RATIO OF RADII, $(\frac{R_e}{r_w})$, DIMENSIONLESS
STRIP WIDTH LENGTH
A 0.020 INCH 6.0 INCH
B 0.040 6.0
C 0.064 6.0
D 0.064 3.0
F 0.040 3.0
G 0.020 3.0
VOLTAGE DROP PER UNIT RATE OF CURRENT FLOW, $(\frac{E_{w_1}-E_{w_2}}{I})$, VOLTS/AMPS.

Fig. 12. Electrical analogy curves showing voltage drop per ampere in vicinity of "well" wall for different copper strips

(Continued from Page 138)

to the well wall. Table 2 summarizes the results.

The results show that the convergence loss is not affected greatly by a two- or three-fold change in the strip width so long as the flow remains either two-dimensional or three-dimensional when the change is made. This fact also is evident from the figure as the three curves for the two-dimensional flow strips are grouped, as are the three curves for the three-dimensional flow strips. A marked decrease in the convergence loss results, however, when a strip length is doubled and the flow changes from three- to two-dimensional. In fact, a comparison between strips A and G, which have the same width, shows that the convergence loss for three-dimensional flow is approximately three times as great as for two-dimensional flow. Similar independent comparisons between strips B and F, which have the same width, and between C and D, which also have the same width, substantiate this result.

Combination of fluid flow and electrical analogy results. The following equation relates the variables of geometrically similar electrical and fluid flow systems provided Ohm's law and Darcy's law are respectively applicable:

$$\frac{dl}{A} = \frac{k}{\mu}\frac{dP}{Q} = \frac{dE}{I\sigma} \quad . \quad . \quad . \quad (8)$$

in which l is a length of the conductor (electrolyte or sand), ft.; A the cross-sectional area presented to flow and, in general, a function of l, sq. ft.; k the sand permeability, sq. ft.; μ the fluid viscosity, lb-sec. per sq. ft.; P the fluid pressure, lb. per sq. ft.; Q the rate of flow, cu. ft. per sec.; E the voltage; I the current flow, amp., and σ the specific resistance of the electrolyte, ohm-ft. If the foregoing units are used, equation (8) will be found to be dimensionally consistent—all members having the units of ft.$^{-1}$ Hence from equation (8):

$$\Delta P = \frac{\Delta E}{I\sigma}\frac{Q\mu}{k} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

As the electrolytic conduction system was geometrically similar to the fluid flow system the value of some particular intercept may be taken from Fig. 12 and used to compute the pressure differential for an analogous fluid flow system in which the fluid viscosity, sand permeability, and volumetric flow rate are specified. For example, the intercept for copper strip, F, is $\left(\frac{\Delta E}{I}\right) = 26.7$ v. per amp. (Fig. 12). The specific resistance (σ) of the test salt solution was 6.88 ohm-ft. During the test of slot F in the fluid flow experiments the viscosity (μ) of the water was 2.54×10^{-5} lb-sec. per sq. ft. and the sand permeability (k) was 53.1×10^{-11} sq. ft. For a flow rate of 1.8×10^{-3} cu. ft. per sec. therefore:

$$\Delta P = \frac{26.7 \times 1.8 \times 10^{-3} \times 2.54 \times 10^{-5}}{6.88 \times 53.1 \times 10^{-11}}$$

$$= 334 \text{ lb. per sq. ft.}$$

In other words, the intercept of the curve for slot F in Fig. 10 would represent a pressure difference of 334 lb. per sq. ft. if the convergence loss had been the only influencing factor, that is, if no bridging or turbulence had been manifest just outside the slot. In the lower left corner of Fig. 10 will be found the designation P_{CF} indicating the magnitude of this computed convergence loss for slot F. The experimental value of the intercept is 2100 lb. per sq. ft., as determined from the fluid flow tests, hence the additional pressure loss resulting from the bridging of the sand over the slot and some turbulence just outside the slot is 2100 — 334 or 1766 lb. per sq. ft. The ratio of the actual experimental loss to the computed convergence loss is 2100/334 or 6.29. It follows that the relationships between slot dimensions and total pressure losses would be indicated if similar ratios were computed for all slots tested and both flow rates used in Figs. 10 and 11, as these ratios are dimensionless and independent of sand permeability and fluid viscosity. The results of the computations are given in Table 3.

EDITOR'S NOTE: This article will be continued in an early issue.

TABLE 2
Results of electrolytic conduction model experiments

Copper strip	Width, in.	Length, in.	Type of flow	Ratio of width of slot to well, diameter	Convergence loss, volts per amp.
A	0.020	6.0	Two-dimensional	0.010	11.0
B	.040	6.0		.020	9.1
C	.064	6.0		.032	7.7
G	.020	3.0	Three-dimensional	.010	30.7
F	.040	3.0		.020	26.7
D	.064	3.0		.032	24.0

TABLE 3
Summary of results

Rate of flow, cu. ft. per sec.	Slot opposite sand	Experimental loss, lb. per sq. ft.	Computed convergence loss, lb. per sq. ft.	Experimental loss minus convergence loss, lb. per sq. ft.	Ratio of experimental loss to convergence loss, dimensionless
1.8×10^{-3}	A	540	118	422	4.58
	B	0	98.8	—98.8	0
	C	—180	84.1	—264	—2.14
	G	5620	260	5360	21.6
	F	2100	334	1766	6.29
0.6×10^{-3}	A	80	39.4	40.6	2.03
	B	—37	33.0	—70	—1.12
	C	—84	28.1	112	—2.99
	G	746	86.8	659	8.59
	F	372	112	260	3.32

Improvement of Petroleum Lubricants By the Addition of Special Ingredients

Oiliness and resistance to oxidation are two most important qualities for which numerous methods of compounding are now available

By ARCH L. FOSTER
Lubri-Zol Corporation, Cleveland, Ohio

WE HAVE discussed in a previous article the methods whereby the best lubricants obtained from mineral oils alone are refined, and the general results obtainable from petroleum hydrocarbons without the use of additional, non-petroleum constituents have been outlined. In the nature of chemical laws, every natural product found in the world or that can be synthesized possesses certain characteristics and properties in varying degrees for any purpose to which that product may be put. Just as inevitably the purposes to which a given product may be applied are limited by the natural properties of that product. To exceed the limitations of those properties is to demand of the product characteristics that are beyond natural laws and to expect results that therefore cannot be realized.

The human organism possesses a degree of extension of capabilities—an endurance under the stress of extra severe conditions that enables that organism to attain results not understandable or explainable on the basis of the capabilities of human beings under ordinary conditions. That flexibility of "characteristics" is due to the fact that the human body is a living entity.

No chemical compound, as we understand it now, and no natural or synthetic chemical product is a living organism. None has any ability, therefore, to extend its degree of possession of properties under any conditions. When the limits of a natural characteristic are exceeded, the chemical or physical elasticity of the material gives way, and the product either ceases to perform its function, or ceases to exist in its former state. These preceding statements are so axiomatic and their connotations are so reasonable that no proof is needed. Yet we think and act counter to the limitations thus imposed in numerous industrial situations. If a steel does not possess the properties necessary to prevent its corrosion or destruction in a still tube, a milling cutter, or an automotive engine, we either accept the inability to perform the service and replace the steel at too-frequent intervals, or we employ a more resistant alloy that does possess the required properties to the necessary degree. If a lightweight cotton fabric is unequal to the work of keeping the human body warm under low temperatures, we employ woolen or silk of the weight necessary to accomplish the desired result.

Yet in the matter of lubrication we have in the past often made demands on the capabilities of natural hydrocarbons that are beyond their limitations, with the result that failure occurred both of lubricant and of machinery on which the lubricant was mis-employed. In general, these axiomatic limitations are recognized in industry and in recent years tremendous strides have been made in the preparation of lubricants possessing properties adequate to the work required of them.

ARCH L. FOSTER

after receiving bachelor's and master's degrees in organic chemistry from the University of Texas in 1922 became affiliated with the research and development division of the Gulf Refining Company, where he remained until 1925 — From 1925 until 1929 he was with the Petroleum Division, U. S. Bureau of Mines, at San Francisco, California, in charge of the chemical research laboratory — During the period, 1927-29, he was assistant to the chief engineer, Petroleum Division, Washington, D.C.— From 1929-39 was technical editor of *The National Petroleum News*, Cleveland, Ohio—In 1939 joined the staff of The Lubri-Zol Corporation as sales engineer, having as his field of activity lubricants and lubricant-treating methods.

The indispensable properties required in a lubricant for any purpose may be reduced to two. The lubricant must be able to carry the load placed on it between the bearing surfaces without permitting metal-to-metal contact, thus preventing excessive wear or attrition of the bearing surfaces. It must maintain its original properties to the degree required to enable it to carry out its first function during its use-life. In briefer statement, the lubricant must have adequate load-carrying capacity, and it must be stable under the conditions existing where it is used.

Recent industrial developments, especially in the automotive and power-generating fields, have accentuated the pressures and temperatures that lubricants must withstand. Automotive engine speeds have increased from 2500-3000 r.p.m. two decades ago to 4000-4500 r.p.m. in 1940. Compression pressures ranged from about 75 to 100 lb. per sq. in. in the engines of 20 years ago. Now, automotive engines using gasoline as fuel employ pressures of 150 lb. or more. Recent introduction of Diesel engines into the automotive field brings compression ratios of 16:1 or more; in gasoline engines, ratios are around 7:1, as compared to 4:1 or 5:1 a few years ago. In aviation engines these ratios may be higher. Main and connecting-rod bearing pressures have doubled during this period of intensive development. A few years ago it was reported (Davis, Lincoln, and Sibley, Proc. A.P.I., Nov., 1935), that a maximum load of 2200 lb. per sq. in. of projected bearing area is reached in a typical connecting-rod bearing at 4500 r.p.m., and that unit loads of 1500 lb. exist during about one-half of each crank revolution. Values for present-day cars doubtless more nearly ap-

proach 3000 and 2000 lb., respectively, under peak operating conditions.

Similarly bearing and engine temperatures are increasing as compression pressures and bearing loads become greater. Momentary loads on Diesel engine crank and connecting-rod bearings probably are several times those obtaining in the gasoline engine. Crankcase oil temperatures of 300-400°F. are reported by various investigators. Internal temperatures of engine bearings are said to be appreciably higher, levels of 400-450°F. having been reported some years ago. Oils are probably exposed to these maximum temperatures only momentarily, yet many of our most serious problems of present-day lubrication are traceable directly to these conditions. The "average" oil temperature now is considerably higher than it was 10 years ago.

In other types of lubrication far greater pressures are attained. It has been determined that temperatures of 400-450°F. and even higher are reached in the body of the lubricant in a hypoid gear, especially when using lubricants showing a high wear factor in service. Poulter points out *(National Petroleum News,* Dec. 29, 1937, p. R-410) that pressures of the order of a half-million lb. per sq. in. are produced momentarily on the tooth surfaces of a hypoid gear, in ball bearings, and in other industrial machinery. This investigator has shown that the physical characteristics of lubricants at ordinary pressures are changed radically under extreme pressures. He suggests that possibly some of the troubles with lubrication may be due to these changes in properties caused by instantaneous and highly localized extreme conditions. He finds that ordinarily fluid lubricants become hard, of the order of hardness of an abrasive, under a half-million lb. pressure, a phenomenon he considers fortunate as otherwise lubrication would fail under many conditions where liquid lubricants are used. He finds that a petroleum lubricating oil will shear particles from a copper wire immersed in the oil at extremely high pressures obtained in the laboratory, the oil becoming a cutting tool under those conditions. Water may be converted under high pressures, to a solid, known as Ice VI, which is very much harder than ice formed at the freezing temperature at atmospheric pressure, and which melts at a temperature approximately that of boiling water at ordinary pressures.

Consequently, our ideas of lubrication must undergo considerable revision as scientific investigation brings to light new laws that govern the behavior of lubricants. We are still faced, however, with the necessity of providing lubricants for industry; lubricants that must be developed partly by scientific methods, partly by the method of "cut and try," until such time as our scientific knowledge is great enough to enable us to understand the fundamentals of lubrication.

The second requirement of a lubricant, chemical and physical stability, is essentially that of resistance to oxidation and polymerization. Oxidation is primarily the reaction in which oxygen from the air is added to a hydrocarbon molecule. Oxidation may and does result in dehydrogenation and the production of olefinic hydrocarbons; polymerization and condensation of these result, with or without the inclusion of oxygen in the new molecule. Further polymerization-condensation reactions continue until we have the products called varnish or lacquer, sludge and the solid or semi-solid materials that deposit in crankcase, combustion chamber, ring grooves, on valves, and elsewhere. Oxidation produces acids and acidic and phenolic bodies that corrode bearings and engine parts, lessen lubricating efficiency, or condense to form the more solid decomposition products. Oxidation, polymerization, and condensation reactions decrease the fluidity, that is, increase the viscosity of the lubricant, and may either decrease or increase the oiliness, film strength, and load-carrying capacity of the oil.

Some inkling of the causes of oxidation and of the products that may form from these reactions may be obtained by reviewing again the principal constituents of a lubricating oil fraction so far as research has disclosed these facts. Aromatic, naphthenic, and paraffinic hydrocarbons are found with molecules composed of innumerable combinations of these typical nuclei. Of these several hydrocarbon complexes, the aromatic types are doubtless the most reactive chemically. The naphthenic nucleus is less reactive than the aromatic, and the paraffinic hydrocarbons are the least reactive of the list. Asphaltenes and similar hydrocarbon complexes are removed from finished lubricants so far as practicable and should not be included as a part of the ideal lubricating oil.

If lubricating oils are composed principally of large aggregations of two or more of these three types of nuclei interconnected, it is easy to see that the complexity becomes baffling, and the susceptibility of the products to oxidation, etc., varies between wide extremes. A preponderance of aromatic nuclei in a molecule would tend to make it more susceptible to attack by atmospheric oxygen. Paraffinic components or paraffinic-naphthenic aggregations will oxidize less rapidly. The presence of sulphur, nitrogen, and such heterogeneous organic bodies in general would tend to increase the instability of the whole lubricant, and may be catalytic in their effect on the remainder of the lubricant's constituents.

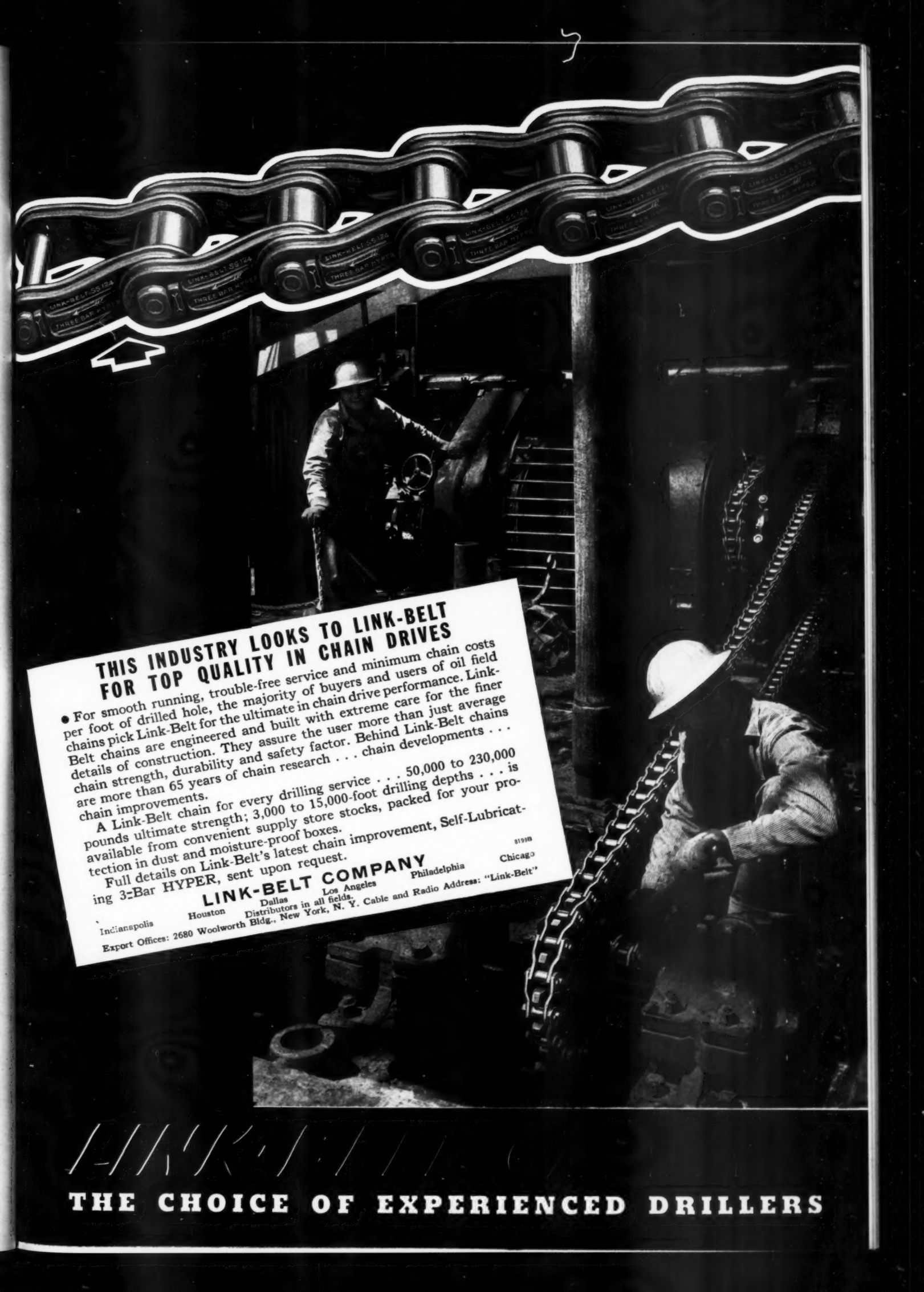
Within certain limits the more "polar" an organic molecule is, the more pronounced are its lubricating qualities of oiliness and film strength. Definitions of these two properties, which are published and in some measure agreed upon by physicists and engineers, still leave something to be desired. The definition agreed upon by the Subcommittee on Oiliness of the Society of Automotive Engineers is as follows:

"Oiliness is a term signifying differences in friction greater than can be accounted for on the basis of viscosity when comparing different lubricants under identical test conditions."

A "polar" molecule is considered to be one in which some group or radical has a greater affinity for the metallic surfaces of bearings and journals than has the remainder of the molecule. For example the carboxyl group in fatty acids. or salts or esters of these acids, —COOH, or —COONa, —COO—CH_3, appear to have residual or secondary affinities or "valences" that cause them to attach the fatty acid molecule to a metal surface, with the carboxyl group adhering relatively tightly to the immediate surface and the rest of the molecule, the long carbon-hydrogen chain extending radially from the surface, streamer-wise. When lubricants incorporating these molecules in even small percentages are used to lubricate a bearing, the "polar" acid molecules are considered to orient themselves on the bearing surface and to resist wiping off, inasmuch as they possess a much stronger affinity for the metal than the relatively non-polar hydrocarbons whose residual valences are comparatively weak.

Many other substances possess this propensity for attachment to metal surfaces, substances that are not strongly reactive in a chemical sense of entering easily into chemical compounds with other materials, but which have a strong polar or orienting power on metals. In fact the less chemically reactive a product is the better it is for a lubricant provided it has the necessary polarity to form a tenacious surface film on metals.

That these polar bodies, these oiliness improvers, do have a special affinity for metals was proved by Burwell and Camelford (*National Petroleum News,* April 20, 1938, p. R-179) by placing various metal powders in a



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technical white oil that had been refined until its own oiliness was at a minimum but to which had been added a quantity of an oiliness improver. The saponification value of the white oil was about 2.0, that of the treated oil about 11.0. The oil removed after intimate contact with the powders of lead, copper, iron, and zinc showed saponification values ranging from 0.28 with copper to 2.24 with zinc, showing that the metals removed most of the oiliness agent from the white oil after only one hour's contact at 140°F. The oil remaining residually on the metal powder was extracted with benzene and carbon tetrachloride, and this extract showed saponification values ranging from 1.10 for zinc to 5.73 for copper, indicating that (1) most of the oiliness agent was removed from the white oil by the metals and (2) that not all of it could be removed from the metals even by these strong solvents.

An interesting aside in this field is that the writer has found acid esters, alcohols, alcohol-ketones, and ketones occurring as natural constituents of lubricating oils, as well as free carboxylic acids and that in some excellent paraffinic-type lubricants the oxygenated products are present in as high as 10-15 percent concentration.

Definitional differentiation between the properties of oiliness and film strength is not easy. Oiliness is defined again in a practical way (Bray, Moore, Jr., and Merrill, S.A.E. *Journal,* Jan., 1939, p. 35.) as that property of a tenacious oil film which reduces wear under normal operating conditions. Film strength is defined loosely as that property which prevents the rupture or breakage of the infinitesimal irregularities of rubbing surfaces under high loads and rubbing speeds, in an emergency, preventing scuffing by violent removal of these protuberances. Film strength prevents the tearing away of metal particles of measurable size, whereas oiliness reduces the rate of wear under normal conditions by removal of sub-microscopic sized particles of metal, under conditions that might give high wear rates with a poorer lubricant but which would not be severe enough to cause scuffing.

Fatty and other organic acids show strong orienting properties on metal surfaces. They are susceptible, however, especially to oxidation, forming gummy products highly undesirable in the engine, and they also tend to become highly corrosive, especially to the hard, alloy-type of modern bearings. Where they have been used successfully they have been robbed of some of their corrosive tendencies by conversion to metallic soaps or esters, and have been made more "polar" by the addition of aromatic or of halogen groups to the main carbon chain. In these forms they have given excellent results, both as oiliness compounds and as detergents.

Certain types of lubrication, such as that required in heavy-duty automotive or high-speed Diesel engines, are improved by the addition of these soaps that serve as detergents. Among these products may be mentioned the calcium soap of dichlorstearic acid, calcium phenyl stearate, methyl, ethyl, and other esters of dichlorstearic acid. These soaps appear to prevent ring-sticking, filling and the fouling of engine parts by a twofold action, a detergent or washing effect, surrounding the particles of foreign or sludgy matter with a film that prevents them coalescing or coagulating to form deposits, and by coating the metal with a "soapy" adherent film that discourages the deposition of sludges, etc., on the surface so coated. Aluminum and calcium naphthenates and calcium oleate have shown similar properties to a strong degree.

Prevention of ring-sticking is credited as being the major purpose of the soap-type of oiliness-detergent additive. Wear on cylinder linings usually averages 0.005 to 0.015 in. per 1000 hr. of running (Bray et al., loc. cit.). With a halogenated stearic acid soap the average wear in a series of Diesel engines was reduced to 0.0017 in. per 1000 hr. Wear was more uniform throughout the piston stroke and showed less tendency to "bell" the liner near top center.

A large number of organic materials other than the soap type have proved to be excellent oiliness and film strength agents. Organic oxygen compounds, especially those having a carbonyl group, —CO—, such as is found in carboxylic acids, in ketones, aldehydes, and those containing the hydroxyl group, —OH, all show higher oiliness properties.

The number of oiliness agents that have been developed or for which patent claims have been issued is legion. More than 80 such patents have been issued during the last two years (*National Petroleum News,* March 6, 1940, p. R-66) covering oiliness agents, for some of which other properties such as oxidation inhibition are claimed. Some of these compounds are:

Organic nitrogen bases esterified with fatty acids.

Nitriles and nitro-amino compounds.

Sulphurized mineral oils.

Oxygenated aromatics, as diphenyl and diphenylene oxide.

Phosphonitrile halides.

Halogenated alkyl toluene, etc.

Alkyl phosphates.

Sulphurized mono- or polyhydric esters of organic acids.

Polychlorinated β-naphthol.

Alkyl ethers of diethylene glycol.

Xanthates.

Stearonitrile.

Alkyl-phenyl oxyether of nitrobenzenes.

The second important property of a lubricant, stability to oxidation and other molecular-structure-changing reactions, is promoted chiefly by addition agents called inhibitors. Oxidation products cause ring-sticking and filling, acid formation and corrosion, sludge deposition, viscosity increase, and changes in oiliness or film strength of the oil. Some authorities have reported that as oxidation proceeds, an increase in oiliness occurs. Burwell and associates (loc. cit.) have shown that oxygen-bearing organic compounds have strong oiliness properties, and that these properties are obtained from oxidized hydrocarbons, natural or synthetic. As oxidation proceeds further the oiliness factor decreases, we are told, indicating the formation of higher oxidation products that possess less of this property than those formed earlier.

Oxidation can be inhibited to a remarkable degree over long periods, at least to the point of reducing the trouble from oxidation products to a negligible minimum over long service periods in severe automotive and other services. Part of the effect of these inhibitors appears to be anti-catalytic, preventing the attack of oxygen by some "protective" influence. It is highly possible, think some lubrication engineers, that the anti-catalytic effect is really a selective absorption of the oxygen by the inhibitor, preventing oil oxidation, the products of which may themselves be catalysts that promote more rapid oxidation. Some of the inhibitor's effect is without doubt the simple absorption, selectively, of

the oxygen of the air in preference to its absorption by the oil.

Some of the numerous inhibitors of oxidation, many of which also exert solvent effects on sludges and deposits, or possess film strength, oiliness, and anti-corrosion properties, are:

Aryl-alkyl-metallo-organic compounds.

Zinc, tin-aromatic stearates.

Alkyl phenol polysulphides.

Halogenated oxygenated and halogenated oxygen-free aromatics.

Quinine, cinchonine, cinchonidine alkaloids.

Amines, mono-, di-, and triphenyl amines, ethanolamines.

Depolymerized rubber, plus amine.

Quinaldine.

Alkyl and aryl phosphites.

Dibutyl phthalate plus polyvinyl acetate.

Alkyl or aryl carbazides.

Esters of alkyl xanthates.

Alkyl iso-thiocyanates.

Butyl-phenol thioether.

Aminoethyl methacrylate.

Amyl-phenol thioether.

This is only a small part of the list of patented products for this general purpose. These materials vary widely in their effectiveness under different lubricating conditions and in their comparative effectiveness in different types of oils. Several of them, including the phosphites, thiocyanates, halogenated organics, amines, phthalates, and some others, are in more or less wide commercial use. When applied intelligently and after individual study of oil and job to be performed they show remarkable results that cannot be duplicated by any naturally occurring or conventionally refined mineral oil lubricant alone. The more severe the service the more the advantage of the use of an effective addition is shown.

A mixture of four parts of tricresyl phosphate and one part of tributyl phosphite is reported to be effective as a "metal deactivator" in lubricants, by Downing, Holbrook and Fuller (Proc. Amer. Chem. Soc., April, 1939). The effect appears to be that of an anti-catalyst, inhibiting the catalytic effect of iron, copper, and other engine metals in promoting oxidation of the oil. The iron in the engine proved to have a much greater effect than did the copper-lead, silver-cadmium, or babbitt-bearing metals. An engine with fully lacquered bearings showed a doubling of the initial viscosity of the oil during a given run of 140 hours with the untreated oil, whereas the treated oil showed less than 40 percent viscosity increase. In a well-lacquered engine—the lacquer was considered to mask the iron of the engine—but using new unlacquered bearings of Cu—Pb, about 45 percent viscosity increase was shown with untreated oil. The treated oil in a similar run gave only half the viscosity increase produced in the untreated oil.

It is not practicable in this limited space to attempt to outline more specifically those reagents that show strong effects particularly against an individual difficulty, such as corrosion, ring-sticking, crankcase sludge, viscosity increase, etc. In general a material that reduces oxidation tendencies automatically affects profitably these various difficulties, although to different degrees. These variations are so innumerable that an individual study of each compound is necessary; even then the experiences of different researchers will not agree. It is this multitude of possibilities, permutations and combinations of effects, properties and tendencies that makes research on lubrication so slow and expensive a process, and which explains the apparent contradictions in results reported by different well-qualified observers.

One phenomenon of which little is known concerning the principles and natural laws involved is that of mutual effects of two or more addition agents when combined within the same compounded lubricant. Frequently two products, each showing a specific advantage as a lubricant additive will, when blended into the same compound, produce an effect that cannot be predicted on the strength of their individual properties—an effect neither shows to any measurable degree when used alone with the same oil. This effect is illustrated especially in recent research work on wear rate reduction, using phosphates, phosphines, and arsines with fatty oiliness agents (Beeck, Givens, Smith, and Williams, Proc. Am. Chem. Soc., September, 1940). Furthermore, an effect produced in one oil may be partly or entirely absent when the same additives are used on another oil of different chemical composition. The only safe rule that can be followed, *without any known exception*, is that of extended study of the effects of a single agent or a group of agents in each oil for which they may be proposed. This investigation should properly include chemical laboratory study of stability and lubricating efficiencies; laboratory engine tests under a variety of conditions that will bring out the good and bad properties of the products, these all to be combined and correlated with tests in the laboratory and in service in commercial engines under the most severe conditions to which the lubricant might be subjected in any service to which it is likely to be put or for which it may be prescribed.

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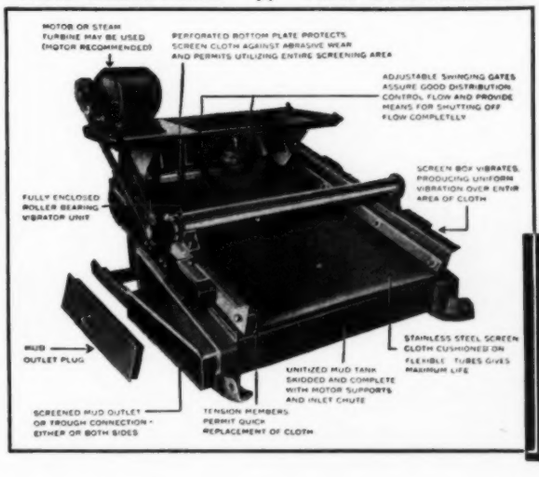
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Vapor-Liquid Phase Equilibria in Hydrocarbon Systems

Part X—Calculation of actual operating conditions of fractionators from minimum reflux and minimum number of plates

By GEORGE GRANGER BROWN
Professor of Chemical Engineering, University of Michigan
and
DYSART E. HOLCOMB

Photographs and biographical sketches of the writers can be found on page 31 of the July issue of *The Petroleum Engineer*, in connection with Part VII.

SINCE the last two installments were written, another method of determining the approximate minimum reflux has appeared[1] using equations for computing the approximate minimum reflux based on somewhat different assumptions than those made in the method of Brown and Martin, who assumed that the ratio between the two cut components in the zone of constant composition in that section of the column having the greater number of plates was approximately the same as the ratio between the two cut components in the liquid part of the feed, as was described in the August installment. Gilliland makes two computations identified as case I and case II and averages the results to obtain the approximate minimum reflux. The following method using individual equilibrium vaporization constants instead of relative volatilities is in effect a simplification of Gilliland's methods.

In case I it is assumed that the ratio between the two cut components in the zone of constant composition is the same as the ratio between these two components on the feed plate and that all components are present in each of the zones of constant composition. This is equivalent to assuming that the two zones of constant composition and the feed plate are all of the same composition.

Equation (39) (August installment) may be solved for the more volatile components in the upper zone of constant composition, giving:

$$x_{a,n} = \frac{Dx_{a,D}}{L(K-1)+KD} \quad \ldots\ldots (39a)$$

A similar solution of equation (40) for the less volatile components in the lower zone of constant composition, gives:

$$x_{h,m} = \frac{Bx_{h,B}}{\overline{L}(1-K)+KB} \quad \ldots\ldots (40h)$$

As it is assumed that the compositions in the two zones of constant composition and on the feed plate are all identical, the summation of $x_{a,n}+x_{b,n}+\ldots+x_{g,m}+x_{h,m}+\ldots$ subtracted from unity will give the summation of the cut component x_c+x_d.

The ratio between the cut components on the feed plate for conditions of minimum reflux, or infinite plates[2]:

$$\left(\frac{x_c}{x_d}\right)_t = \frac{Fz_c+\left(\frac{V}{\overline{V}}-1\right)Bx_{c,B}}{Fz_d+\left(\frac{V}{\overline{V}}-1\right)Bx_{d,B}} \quad (41)$$

may be combined with this summation giving Gilliland's equation for case I. See equation (42).

In using equation (42), the value for $\left(\frac{x_c}{x_d}\right)_t$ is obtained from equation (41); x_a, x_b, and $x_{c,n}$ are obtained from equations (39a), (39b), and (39c), and x_g, x_h are obtained from equations (40g) and (40h) by assuming a value for the minimum reflux and using the value for K at the approximate temperature of the feed plate. Equation (42) is preferred when the summation $x_a+x_b+\ldots$ is greater than the summation of $x_g+x_h+\ldots$ as computed for the zones of constant composition by equations (39) and (40), respectively. If the opposite is true, equation (43) is preferred, which is derived in exactly the same manner except that $x_{d,m}$ as computed from equation (40) is used instead of $x_{c,n}$ as computed from equation (39).

Both of these equations give approximately the same results, and are rather insensitive to the assumed value for the minimum reflux that must be used in solving equations (39), (40), and (41). For example, in Table 21, there is no significant difference in the calculated minimum reflux for case I whether the assumed minimum reflux is correct or somewhat more than 10 percent in error.

The values for the equilibrium va-

[1] Gilliland, *Ind. Eng. Chem.*, Vol. 32, No. 8, p. 1101 (August, 1940).

[2] Underwood, *Trans. of the Institution of Chemical Engineers*, London, Vol. 10, p. 114 (1932).

NOMENCLATURE

F = total moles of feed per unit time, as subscript feed.
D = total moles of overhead distillate, as subscript distillate.
B = total moles of bottom product, as subscript bottoms.
L = moles of liquid flowing down the column above the feed plate.
$\overline{L}$ = moles of liquid flowing down the column below the feed plate.
V = moles of vapor flowing up the column above the feed plate.
$\overline{V}$ = moles of vapor flowing up the column below the feed plate.
y = mole fraction of a component in the vapor.
x = mole fraction of a component in the liquid.
K = y/x under equilibrium conditions.
z = mole fraction of a component in the total feed.
a, b, ... g, h, ... = subscripts used to indicate a particular component in order of decreasing volatility.
c and d = subscripts used to designate the more volatile and less volatile cut or key components, respectively.
n = a plate above the feed plate numbered from top downward. (In the case of minimum reflux, a plate in the zone of constant composition above the feed plate.)
m = a plate below the feed plate numbered from top downward. (In the case of minimum reflux, a plate in the zone of constant composition below the feed plate.)
N = total equilibrium steps (including the reboiler and partial condenser, if used), required in a fractionating column operating at a finite reflux.
$N_{(r=1)}$ = minimum number of equilibrium steps (including the reboiler and partial condenser) required in a column operating at total reflux.
min. = subscript used to indicate minimum values.
f = subscript used to designate feed plate.

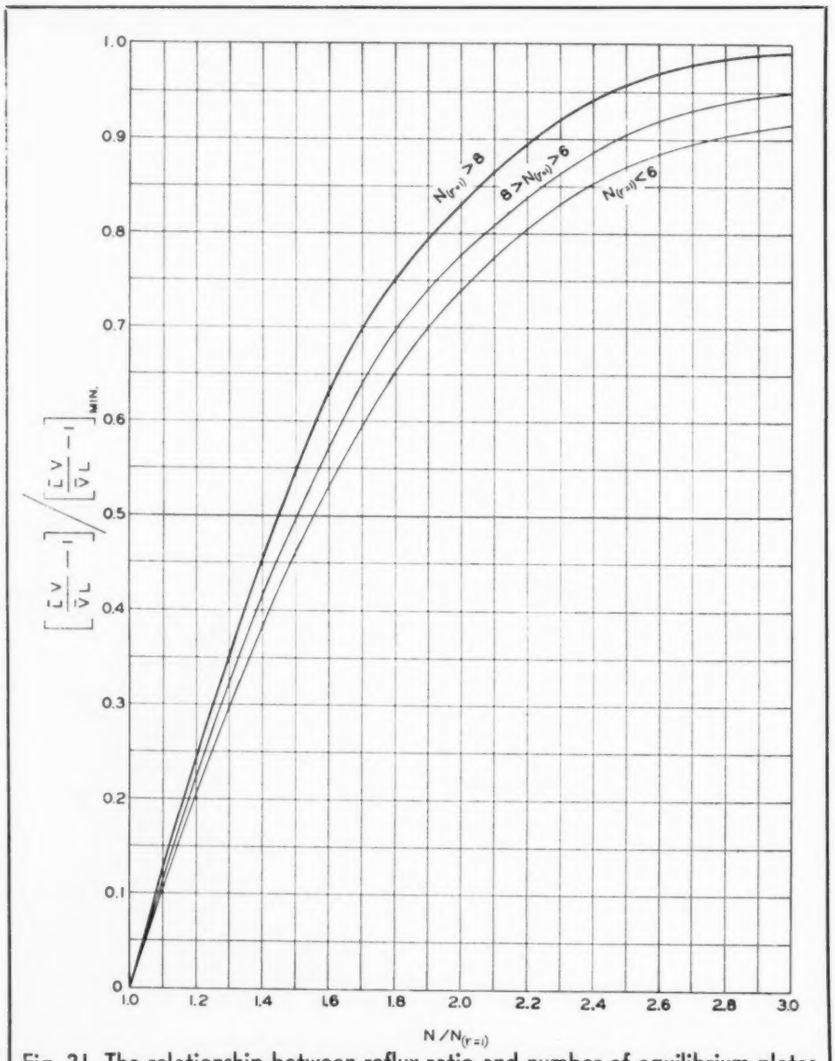

Fig. 21. The relationship between reflux ratio and number of equilibrium plates in fractionating columns *(Brown and Martin, Trans. A.S.Ch. E., Vol. 35, No. 5, 679, October, 1939)*

porization constants should be taken at the approximate temperature of the feed plate, which can usually be estimated but can be readily checked by applying equation (35) (June installment) if thought desirable.

It is possible to make a direct match of the ratio between the cut components in the two zones of constant composition without regard to the approximate ratio at the feed plate as provided by equation (41). If this is done, a complicated quadratic equation results, which on solution gives approximately the same values as obtained from the use of the simpler equations (42) or (43).

In case II the same basic assumption that the ratio between the cut components is the same in the two zones of constant composition is made, but the effects of the less volatile and more volatile components and of the feed introduced between the two zones of constant composition are neglected.

In order to avoid the use of the complicated quadratic equation, it is necessary to use an expression giving the approximate ratio between the two cut components on the feed plate. Equation (41) gives different results for the rectifying and stripping sections of the column in this case because the effect of the more volatile and less volatile components has been neglected. It is necessary, therefore, to use an approximate expression for the ratio between the two cut components that may be combined with equations (39) and (40) according to the assumptions of case II. Gilliland's equation giving the approximate ratio between the cut components is:

$$\left(\frac{x_c}{x_d}\right)_{m,n} = \frac{Fz_c + \left[\frac{V}{\overline{V}}\frac{(1-y_a-y_b+..)}{(1-y_g-y_h+..)}\right]Bx_{c,B}}{Fz_d + \left[\frac{V}{\overline{V}}\frac{(1-y_a-y_b+..)}{(1-y_g-y_h+..)}\right]Bx_{d,B}} \quad (44)$$

In this equation the values for y_a, y_b, etc. are obtained by multiplying the corresponding value of x_a, x_b from equation (39) by the corresponding values for the vaporization equilibrium constant as indicaed by equation (32):

$$y = Kx \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

Similarly the values for y_g, y_h, etc. are obtained by multiplying the values of $x_g x_h$ obtained from equation (40) by the corresponding values for the vaporization equilibrium constants.

Because in case II there are considered to be none of the less volatile components in the section above the feed plate, the match in the ratio between the cut components is obtained by combining the summation of the mole fractions of the more volatile components, $x_a + x_b + ..$ as obtained from equation (39) with the ratio between the cut components indicated by equation (44). In this manner equation (45) may be derived by a process similar to that used in obtaining equations (42) and (43).

EQUATION (42)

$$\left(\frac{L}{D}\right)_{min.} + 1 = \left[\frac{x_{c,D}}{\left(\frac{x_c}{x_d}\right)_f (K_c - K_d)} - \frac{x_{d,D}}{(K_c - K_d)}\right]\left\{K_c\left(\frac{x_c}{x_d}\right)_f + K_d + \left(\frac{x_c}{x_d}\right)_f\left(\frac{1}{x_{c,n}}\right)\left[(K_a x_a + K_b x_b + ..) + (K_g x_g + K_h x_h + ..)\right]\right\}$$

EQUATION (43)

$$\left(\frac{L}{D}\right)_{min.} + 1 = \left[\frac{x_{c,D}}{\left(\frac{x_c}{x_d}\right)_f (K_c - K_d)} - \frac{x_{d,D}}{(K_c - K_d)}\right]\left\{K_c\left(\frac{x_c}{x_d}\right)_f + K_d + \left(\frac{1}{x_{d,m}}\right)\left[(K_a x_a + K_b x_b + ..) + (K_g x_g + K_h x_h + ..)\right]\right\}$$

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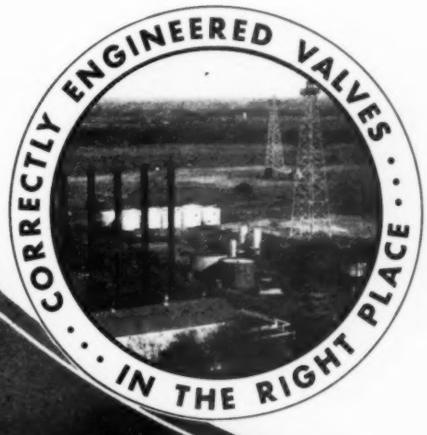
Fig. 1878



Iron

Fig. 1430

Steel

Fig. 1938

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TABLE 21

Calculation of the approximate minimum reflux by use of equations (44), (45), (47), and (48)

Assumed $(L/D)_{min.}$	Equation used for computing $(L/D)_{min.}$	Computed $(L/D)_{min.}$
Case I		
1.78	(44)	2.02
1.78	(45)	2.46
2.0	(44)	2.025
2.0	(45)	2.42
Case II		
1.45	(47)	1.49
1.45	(48)	1.53
1.50	(47)	1.50
1.50	(48)	1.49

$$\text{Approximate } (L/D)_{min.} = \frac{1.50 + 2.025}{2} = 1.763$$

$$(L/V)^{*}_{min.} = \frac{1.763}{(1.763 + 1)} = 0.638$$

*Intermediate steps:

$$L+D=V$$

$$L/V = 1 - \frac{D}{V} = \frac{D+L}{D+L} - \frac{D}{D+L} = \frac{L/D}{L/D+1}$$

By following the same procedure but using the summations of the mole fractions of the less volatile components, x_g, x_h + . . as obtained from equation (40) and the ratio between the cut components as indicated in equation (44), equation (46) may be obtained.

In equations (45) and (46):

$\left(\frac{x_d}{x_c}\right)_{m,n}$ is obtained from equation (44)

x_a, x_b . . ., $x_{c,n}$ are obtained from equation (39)

and x_g, x_h . . ., $x_{d,m}$ are obtained from equation (40).

In general it was found that equations (45) and (46) give very similar results.

Gilliland recommends that the lower value for the minimum reflux ratio (L/V) as obtained from either equation (42) or (43), be averaged arithmetically with the value obtained from either equation (45) or (46) to obtain the approximate minimum reflux ratio.

Equations (42), (43), (45), and (46) are rather insensitive to the assumed value for L/D and if a reasonably close approximation has been assumed (say within ±20 percent) the values obtained by solution of these equations may be used without further calculation.

As indicated in Table 22, the assumptions made pertaining to the ratio between the cut components in the zones of constant composition, on the feed plate, or in the liquid feed for either the method suggested by Brown and Martin or by Gilliland, are not fulfilled in practice. The values given in Table 22 are those obtained by a careful plate-to-plate computation of the minimum reflux as set forth in Tables 17, 18, and 19 and as plotted in Fig. 19. The approximate methods give reasonably satisfactory results, however, which are very useful in connection with a complete economic study of a fractionating problem.

Relationship Between Reflux Ratio and Number of Equilibrium Plates

An empirical relationship based on 220 careful calculations of various binary mixtures was found between actual reflux and minimum reflux and the actual number of plates and the minimum number of plates shown as in Fig. 21, which is reproduced from Brown and Martin.[3] The curves in Fig. 21 reproduced the computed data with an accuracy of within ±5 percent. The relationship was based on computations of binary mixtures so as to avoid any uncertainty that might be introduced in the computation of the minimum number of plates and the minimum reflux ratio for complex mixtures as it would have been a most laborious task to compute the correct actual minimum reflux for a large number of complex mixtures.

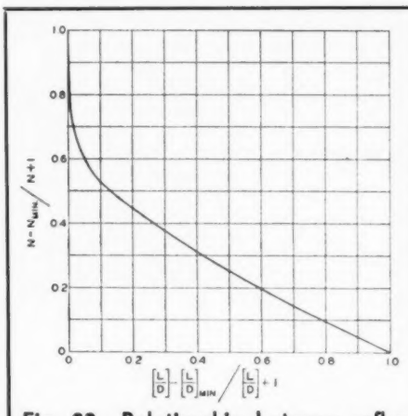


Fig. 22. Relationship between reflux ratio and number of equilibrium plates ***(E. R. Gilliland, Ind. Eng. Chem., 32, No. 9, 1220, 1940)***

TABLE 22

Ratio of concentrations of cut components at different sections in the column for the column making the separation given in Table 9 when operating at minimum reflux

Point in column for computed ratio of cut components	Ratio between cut components x_{iC_4}/x_{nC_4}
Plate n	0.493
Feed plate	0.507
Plate m	0.579
Liquid feed	0.416

Table 23 gives the reflux ratio and the corresponding number of equilibrium steps (or plates) including the reboiler and the partial condenser, required for the separation of Table 9 as computed from this plot (Fig. 21) using the actual minimum number of equilibrium plates as computed for this separation in the July installment, the actual minimum reflux as computed in the September installment, and the approximate minimum reflux as computed by Gilliland's method as set forth herein, and as computed in the August installment by the method of Brown and Martin.

Although the differences between the approximate minimum reflux ratios (L/V) and the actual minimum reflux ratio (L/V) are in this case as great as 3.7 percent, the differences in the number of equilibrium steps or plates required are insignificant until the actual reflux ratio used as given in the first column comes within 10 percent of the approximate minimum reflux ratio.

In making an economic study of a fractionation problem, the use of the approximate minimum reflux ratio is usually satisfactory, as the result of such a study would lead to the use of the correct number of plates, but the actual reflux required in operation might be some 5 percent less than that estimated from such a study using the approximate minimum reflux ratio. Or putting it another way, the distillate recovered might be increased by as much as 10 percent over the estimated capacity of the column.

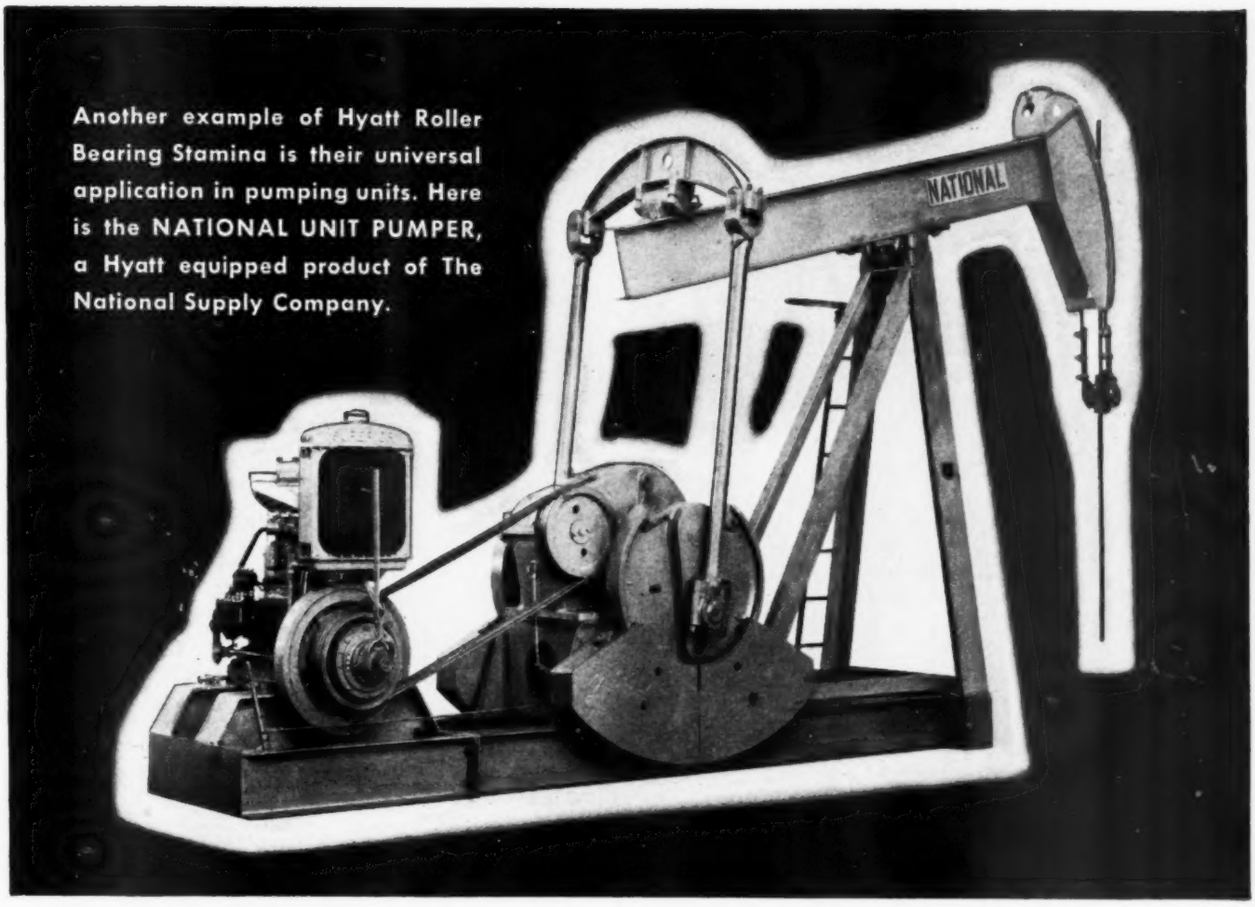
[3] *Trans. Amer. Inst. Chem. Engrs.*, Vol. 35, No. 5, Oct. 25, 1939, p. 679-708.

EQUATION (45)

$$\left(\frac{L}{D}\right)_{min.} + 1 = \left[\frac{x_{c,D}}{\left(\frac{x_c}{x_d}\right)_{m,n}(K_c - K_d)} - \frac{x_{d,D}}{(K_c - K_d)}\right]\left[K_c\left(\frac{x_c}{x_d}\right)_{m,n} + K_d + \left(\frac{x_c}{x_d}\right)_{m,n}\left(\frac{1}{x_{c,n}}\right)(K_a x_a + K_b x_b + \ldots)\right]$$

EQUATION (46)

$$\left(\frac{L}{D}\right)_{min.} + 1 = \left(\frac{L - \overline{L} + F}{D}\right) + \left(\frac{B}{D}\right)\left[\frac{x_{d,B}}{(K_c - K_d)} - \frac{x_{c,B}}{\left(\frac{x_c}{x_d}\right)_{m,n}(K_c - K_d)}\right]\left[K_c\left(\frac{x_c}{x_d}\right)_{m,n} + K_d + \left(\frac{1}{x_{d,m}}\right)(K_g x_g + K_h x_h + \ldots)\right]$$



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As these differences are no more than should ordinarily be allowed in the computation of fractionating equipment, the use of the approximate minimum reflux as computed either by the method of Brown and Martin or by the equations of Gilliland, have proved satisfactory as a basis for making economic studies of fractionating problems in connection with Fig. 21.

Even more recently Gilliland[4] has presented charts somewhat similar to that of Fig. 21 for which an accuracy of 7 percent is claimed independent of the conditions of the feed and the minimum number of plates. Comparison with the data used in developing the relationship of Fig. 21, indicates an error of ±20 percent for the curves of Fig. 22 as given by Gilliland. The discrepancy may be due in part to the fact that minimum plates were computed accurately in the development of Fig. 21, whereas Gilliland used only an approximate method based on equation (38) as given in the July installment without making the plate-to-plate calculations that have been found necessary for a reliable computation of the minimum number of plates.

The equilibrium steps computed by Fig. 22 for the separation of Table 9 are given in the last three columns of Table 23.

Fig. 22 has been reported as applicable to all conditions of feed. Although Fig. 21 was derived from data on fractionations involving feed in the liquid state at its boiling point, the errors when using Fig. 21 for different conditions of feed are no greater than those involved in the use of Fig. 22.

An interesting comparison between the computed results set forth in Table 23, and an actual commercial operating column is afforded by a study made some years ago on a gasoline stabilizer[5] wherein a separation very similar to that of Table 9 is accomplished. The actual separation is given in Table 6 in the May installment. The actual column was operating with an internal reflux ratio (L/V) of 0.785 and contained 31 plates in addition to the reboiler at the bottom and a partial condenser at the top. A detailed study of those particular operating conditions indicated an overall plate efficiency of 80.5 percent corresponding to 25 equilibrium plates or 27 equilibrium steps including the reboiler and partial condenser.

The total minimum plates required for the separation of Table 9 was computed to be 16.7 as given at the bottom of Table 23. The minimum plates required for the separation of Table 6, which is the separation on which this commercial column was operating, was computed to be 19.6. The difference is due primarily to the propane present in the bottom product of the actual column. Using 19.6 as the minimum number of plates with the minimum reflux L/V = 0.618, Fig. 21 indicates 27.2 as the number of equilibrium steps required for the actual reflux ratio (L/V = 0.785), compared with the 27 indicated by the study of the actual column.

As an interesting indication of the errors introduced in computing the minimum number of plates when equation (38) is applied over the entire column between the overhead distillate and the bottoms product, this procedure has been followed for each of the separations given in Table 6 and Table 9. The minimum number of plates thus computed for the separation of Table 9 is 14.8 as compared with 16.7 when computed in the correct manner as described in the July installment. This indicates an error of 12.8 percent in this calculation. Similarly the application of equation (38) to determine the minimum number of plates between the overhead distillate and the bottoms product for the separation of Table 6 indicated 14.8, the same number of minimum plates as for Table 9. In this case an error of more than 32 percent is indicated.

The effect of the components other than the cut components should be considered in computing the minimum number of plates as they have an important effect at the top and the bottom of the columns in a manner similar to the effect of these components on the fractionation when computing the minimum reflux as has been fully described and illustrated in the last two installments.

In the next installment the thermal properties of the natural gasoline hydrocarbons will be given, and their use demonstrated in making heat balances preliminary to an economic study of the separations of Table 6 (May installment).

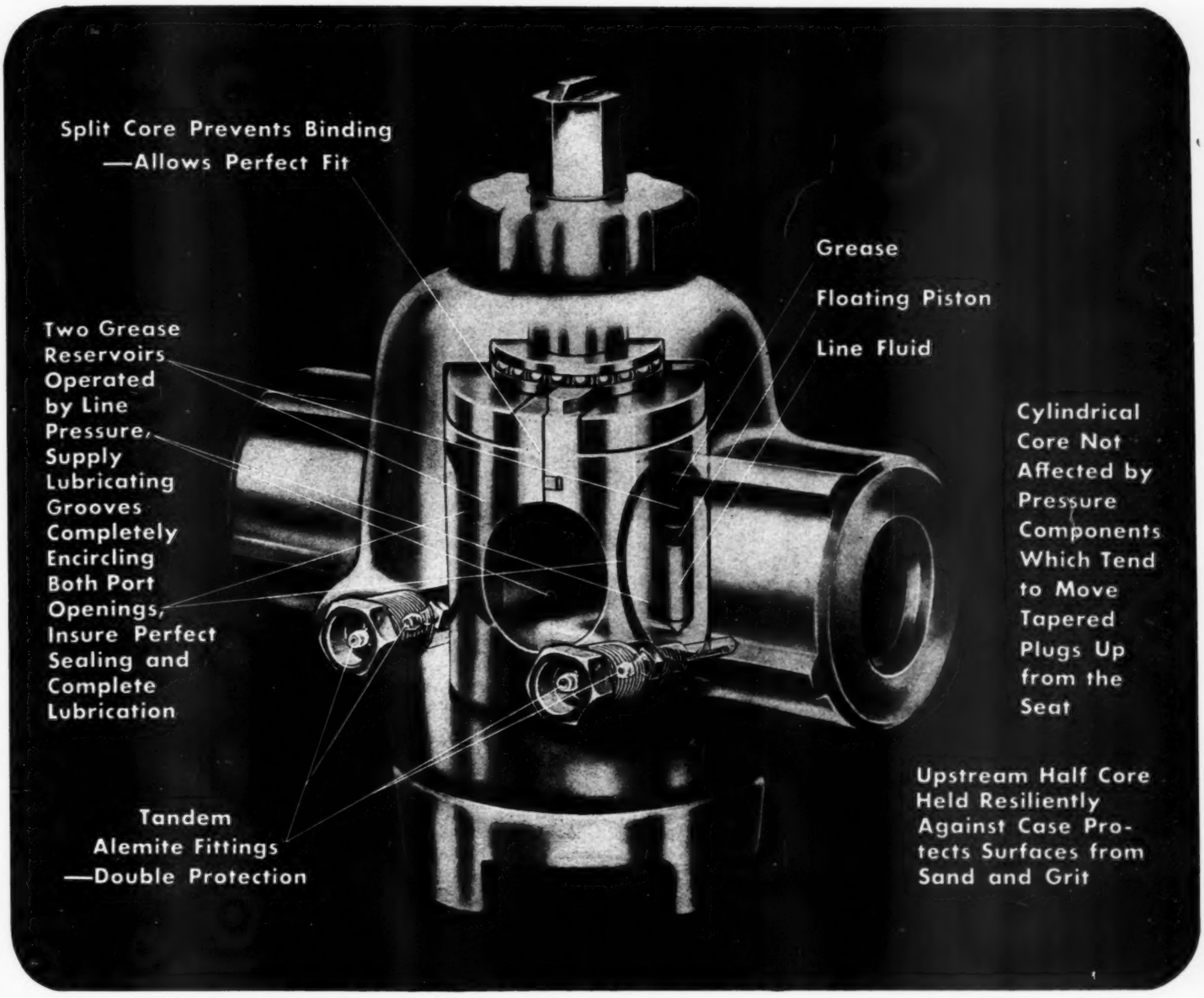
[4] *Ind. Eng. Chem.*, Vol. 32, No. 9, p. 1220 (Sept., 1940).

[5] Brown, G. G., *Trans. Amer. Inst. of Chem. Engrs.*, Vol. 32, No. 3 (1936).

TABLE 23

Relationship between reflux ratio, L/V, and equilibrium steps, N, for separation of Table 9

Operating reflux ratio		$\left(\frac{\bar{L}V}{\bar{V}L}-1\right)_{min.}$ using:							Total equilibrium steps								
									Using Fig. 21						Using Fig. 22		
									Using:			Using:			Using:		
			Actual minimum reflux ratio	Approximate minimum reflux ratio of:					Actual minimum reflux ratio	Approximate minimum reflux ratio of:		Actual minimum reflux ratio	Approximate minimum reflux ratio of:		Actual minimum reflux ratio	Approximate minimum reflux ratio of:	
				Gilliland	Brown and Martin					Gilliland	Brown and Martin		Gilliland	Brown and Martin		Gilliland	Brown and Martin
		Col. 2 ÷ Col. 1 minus Col. 1	$\left(\frac{L}{V}\right)=0.618$ min.	$\left(\frac{L}{V}\right)=0.636$ min.	$\left(\frac{L}{V}\right)=0.641$ min.				$\left(\frac{L}{V}\right)=0.618$ min.	$\left(\frac{L}{V}\right)=0.636$ min.	$\left(\frac{L}{V}\right)=0.641$ min.	$\left(\frac{L}{V}\right)=0.618$ min.	$\left(\frac{L}{V}\right)=0.636$ min.	$\left(\frac{L}{V}\right)=0.641$ min.	$\left(\frac{L}{V}\right)=0.618$ min.	$\left(\frac{L}{V}\right)=0.636$ min.	$\left(\frac{L}{V}\right)=0.641$ min.
L/V	$\bar{L}/\bar{V}$					Col. 3 ÷ Col. 4	Col. 3 ÷ Col. 5	Col. 3 ÷ Col. 6	$N/N_{(r=1)}$	$N/N_{(r=1)}$	$N/N_{(r=1)}$	No. of equilibrium steps N	No. of equilibrium steps N	No. of equilibrium steps N	No. of equilibrium steps N	No. of equilibrium steps N	No. of equilibrium steps N
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0.65	1.506	1.317	1.52	1.40	1.37	0.866	0.941	0.961	2.085	2.350	2.450	34.80	39.20	40.90	37.55	48.20	49.60
0.70	1.437	1.053	1.52	1.40	1.37	0.693	0.750	0.769	1.680	1.795	1.830	28.05	30.00	30.55	30.20	32.40	32.40
0.80	1.290	0.613	1.52	1.40	1.37	0.403	0.438	0.447	1.340	1.375	1.390	22.40	22.95	23.20	23.00	23.55	23.65
0.90	1.145	0.272	1.52	1.40	1.37	0.179	0.194	0.199	1.150	1.160	1.165	19.20	19.37	19.46	19.17	19.34	19.34
0.95	1.071	0.127	1.52	1.40	1.37	0.084	0.091	0.093	1.070	1.075	1.075	17.88	17.97	18.03	17.82	17.86	17.86
1.00	1.000	0	1.52	1.40	1.37	0	0	0	1.000	1.000	1.000	16.70	16.70	16.70	16.70	16.70	16.70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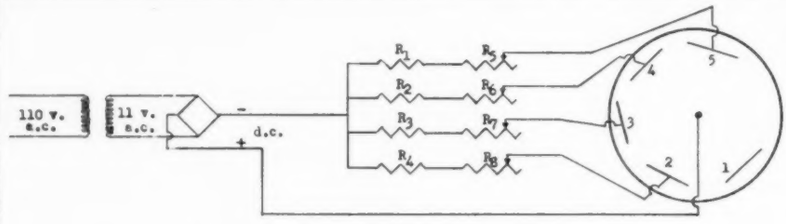


R_1 = 5.05 Ohms — R_5 = 10,000 Ohms-10 Watts
R_2 = 2.12 Ohms — R_6 = 10,000 Ohms-10 Watts
R_3 = 1.05 Ohms — R_7 = 10,000 Ohms-50 Watts
R_4 = 1.05 Ohms — R_8 = 10,000 Ohms-100 Watts

Sheet iron specimens No's 1-5, 5"x10"x20 gauge.

Fig. 1. Apparatus for determining effect of current density in reducing corrosion of steel

By

WALTER F. ROGERS

Gulf Oil Corporation

Relationship of Current Density To Cathodic Protection

Laboratory and field tests indicate current density is better criterion of protection on bare or poorly-coated pipe than pipe-to-soil potential

IN view of the seasonal variations of pipe potentials with their attendant difficulty of interpretation it was decided to augment the investigations[1] by a study of the effect of current density on soil corrosion and determine if measurements of this factor are better indexes of protection for bare pipe than are pipe-soil potentials. The purpose of such a study was to learn the minimum amount of current necessary per unit area of bare pipe to give protection.

Laboratory tests were made to obtain this information using apparatus, the wiring diagram of which is shown in Fig. 1. The apparatus consists essentially of a source of alternating current, a rectifier to convert this current to direct current, a set of variable resistances to control the current drained by each cathodic test specimen, a set of fixed resistances (the potential drop across each being used as the index of current flow), a carbon anode, a set of cathode test specimens, and a jar for holding the specimens and the fluid or soil in which the test is made.

In each test 5 specimens were used. One was left undrained (electrically) as a measure of the corrosion without any protection. The other specimens drained 0.002, 0.004, 0.008, and 0.016 amp. per sq. ft. of surface, respectively. The container used for these tests was a 10-gal. earthenware jar. Its diameter was 13 in. The specimens were 5-in. by 10-in. by 20-ga. black sheet iron. The specimens were cleaned before and after each test and weighed to the nearest 0.01 g. In beginning a test, all specimens were placed in their proper positions in the corrosive environment in the jar and the electrical connections made as shown in Fig. 1. When the medium was a fluid, an electric stirrer was used to agitate the solution in order to increase the corrosion rate. When the environment was a soil, the stirrer was omitted. A 0-16 mv. range potentiometer was used to measure the potential drop across the fixed resistances, R_1 to R_4. The desired potential drop across each of these resistances was calculated from the known value of the resistance and the desired current drainage. The current through the variable resistances was adjusted until the potential drop across each resistance attained the desired value. These values were checked twice daily during each test. The period of test was 120 hr. in each case. Tests were made at room temperature.

The calculation of desired potential drop across each fixed resistance is given in Table 1.

[1] "Pipe-to-Soil Potentials in Cathodic Protection Systems" by Walter F. Rogers, *The Petroleum Engineer*, September, 1940.

WALTER F. ROGERS

was born April 3, 1905, at Tyler, Texas — Graduated from Tyler High School in 1922—Graduated from University of Pittsburgh with degree of B.S. in chemical engineering in 1926 —Received professional degree in chemical engineering from University of Pittsburgh in 1933 — Began work for Gulf Refining Company at Port Arthur in 1926—Transferred to chemical laboratory of Gulf Oil Corporation, Houston, Texas, in 1927 where he is still employed—Has specialized in studies of corrosion of production and pipe-line equipment.

TABLE 1

Measurement of current density test values

Desired current, amp. per sq. ft.	Specimen size, sq. ft., both sides	Current per specimen, amp.	Resistance, ohms.	Potential drop, volts
0.002	25 to 36	0.00138	5.05	0.0070
0.004	25 to 36	0.00277	2.12	0.0069
0.008	25 to 36	0.00554	1.05	0.0058
0.016	25 to 36	0.01108	1.05	0.0117

Test 1 was made using Houston, Texas, tap water to which sodium chloride was added to decrease its resistance. The fluid analysis is:

Houston Tap Water Analysis

$NaHCO_3$	0.8 g.per gal. as $CaCO_3$
$Ca(HCO_3)_2$	13.4 g.per gal. as $CaCo_3$
NaCl	271 g.per gal.
Na_2SO_4	12.9 g.per gal.
SiO_2	0.4 g.per gal.
pH	8.1

The initial and final values of specimen potential and the amount of protection are given in Table 2. Test 2 was conducted as a duplicate of Test 1. The data are given in Table 3.

TABLE 2

Current density vs. protection

Test 1

Original potential of specimen, volts	Final potential of specimen, volts	Current density, amp. per sq. ft.	Weight loss, grams	Percent reduction in corrosion
0.65	0.65	zero	0.96	zero
0.62	0.77	0.002	0.56	45.8
0.64	0.81	0.004	0.35	63.5
0.68	0.76	0.008	0.35	63.5
0.72	1.+	0.016	zero	100

TABLE 3

Current density vs. protection

Test 2

Original potential of specimen, volts	Final potential of specimen, volts	Current density, amp. per sq. ft.	Weight loss, grams	Percent reduction in corrosion
0.58	0.58	zero	0.98	zero
0.70	0.73	0.002	0.50	49.0
0.71	0.73	0.004	0.28	71.5
0.63	0.71	0.008	0.19	80.5
0.61	0.69	0.016	0.01	99.0

Test 3 was made in an artificial soil. A coarse, washed river sand was used as the base. To this was added aluminum sulphate to impart an acid reaction to the soil and to decrease its resistance. The soil was then partly saturated by distilled water to the extent of 13 percent by weight of the sand. The soil was well-mixed and the sand well-packed around the test specimens. Some data on this soil are:

Soil pH:

Top of jar 6.0

Center and bottom of jar . 4.5

Soil resistivity, ohm-cm. . . 5600

The results of Test 3 are given in Table 4.

TABLE 4

Current density vs. protection

Test 3

Original potential of specimen, volts	Final potential of specimen, volts	Current density, amp. per sq. ft.	Weight loss, grams	Percent reduction in corrosion
0.61	1.+	zero	1.59	zero
0.60	1.+	0.002	0.73	54.2
0.61	1.+	0.004	0.47	70.3
0.58	1.+	0.008	0.28	82.4
0.61	1.+	0.016	0.10	93.7

The data from these three tests check very well as regards the amount of protection given in each case for the different current densities. For instance, 0.002 amp. per sq. ft. resulted in a range of 45.8 to 54.2 percent protection; 0.004 amp. per sq. ft. gave 63.5 to 71.5 percent protection; 0.008 amp. per sq. ft. gave 63.5 to 82.4 percent protection, and 0.016 amp. per. sq. ft. gave 93.71 to 100 percent protection. It is believed that these values are directly applicable to severely corrosive soil conditions, as the solutions and the soil used were rapidly corrosive. It is of interest to observe that the metal-copper sulphate electrode potentials for the two tests employing solutions, began at high values, indicating probably the approach of the specimen to the ferrous-electrode potential. In only two of the final potential values was 0.80 v. exceeded; the normal voltage increase for all but one case was 0.03-0.17 v. including the fluid IR drop, showing that the specimens were only partly polarized. In one case where a drainage of 0.016 amp. per sq. ft. existed, the final voltage represented an increase of more than 0.28 v., indicating complete hydrogen polarization.

Keeling[2] has published data that agree very well with these tests. He determined the effect of current density on protection by test coupons tied to existing cathodically protected lines in sea water, and by laboratory tests made in 3 percent salt water. Among others, one conclusion was: "The average unit current density required for the complete cathodic protection of bare steel in sea water is about 15 milli-amperes per square foot, with possible extreme values of 7 to 25 milli-amperes per square foot."

A check was next made in the field to determine if the values obtained in tests 1 to 3 were directly applicable in an actual corrosive soil. The tests were made along a system of seven parallel bare pipe lines that were electrically protected. These lines were receiving an average current of 0.004 amp. per sq. ft. Six test sites were selected. At each site a test coupon was attached to the pipe using a ¼-in. diameter copper rod; another coupon was placed 6 in. from the first and left unconnected to the pipe. The specimens were 2-in. by 3-in. sheets of ⅛-in. cold-rolled, low-carbon steel. They were cleaned and weighed before and after the test. The specimens were buried at pipe-bottom level, the dirt was well packed around them, and they were left in place for 147 days. The data obtained, listed in Table 5, show for this case that current densities of

TABLE 5

Field test of current density vs. corrosion rate

Line no. and size, in.	Mile post no.	Wgt. loss unprotected, grams	Wgt. loss protected, grams	Percent protected	Current density, milliamp. per sq. ft.
3- 8	32.00	1.775	0.028	98.4	3.65
3- 8	32.125	0.382	+0.052*	100.0	4.95
3- 8	33.25	1.330	0.316	76.2	6.40
1-10	32.00	.....	0.000	100.0	3.65
1-10	32.125	0.496	0.004	99.0	3.30
1-10	33.25	1.289	0.230	82.1	8.20

*gain in wgt.

3.65 to 8.20 milliamperes per sq. ft. were being obtained and that this current density resulted in 76.2 to 100 percent protection. It is also of interest to note that during at least 60 of the 147 days of test, the pipe potentials varied from 0.60 to 0.80 v. or were below the so-called minimum protection potential. The percent-protection data are in line with those determined experimentally and indicate for bare or poorly coated pipe that more attention should be paid to this measurement than to pipe-soil potential measurements.

Acknowledgment

The writer wishes to thank the Executive Department of the Gulf Oil Corporation for permission to publish this article.

EDITOR'S NOTE: Another article on cathodic protection by the same writer will appear in an early issue.

[2] "Current and Voltage Needs for the Cathodic Protection of Steel Submarine Pipe Lines," by H. J. Keeling, *Gas*, p. 31, September, 1939.

Running Tour
WITH MEN IN THE INDUSTRY

DR. J. HUENER, New Orleans, formerly assistant state geologist for Louisiana, has been made state geologist to succeed **CYRIL K. MORESI,** who resigned recently.

P. O. TETER, who has been tender representative, is the new superintendent of the East Texas district for Empire Pipe Line Company, succeeding **N. G. MOORE,** who resigned to become general superintendent for Pan American Pipe Line Company, Houston, Texas.

DR. RUDOLPH SCHIDER, geologist for the Asiatic Petroleum Company, and **G. K. KAUFMAN,** chief geologist for Standard Oil Company of Venezuela, returned to Venezuela recently after spending some time in the United States.

J. W. BELL, purchasing agent for Moose Dome Oils, Ltd., now makes his headquarters at Winnipeg, Canada. He has been at Calgary.

R. E. ALLEN, San Gabriel, California, consulting engineer, has been made chairman of the Alberta, Canada, Conservation Board to succeed **W. F. KNODE,** who resigned some time ago. **C. W. DINGMAN,** who has been acting chairman, has announced his resignation as a member of the board.

EDWARD L. STEINIGER, vice-president of the Venezuela Petroleum Company, returned to Venezuela from the United States recently. He was accompanied by Mrs. Steiniger.

EARNEST B. WILSON, who has been chief assistant to **STANLEY GILL,** consulting geologist of Houston, Texas, has accepted the position of chief geologist of the Hogg Oil Company, Houston.

LLOYD LOCHRIDGE, Sinclair Refining Company, Wellsville, New York, has been chosen a director of the Pennsylvania Grade Crude Oil Association. He succeeds **HARRY L. LEWIS,** of the Conewango Refining Company, resigned.

T. H. PIKE, JR., who for a number of years represented the W. R. Guiberson Company in California, has recently joined the sales staff of Tube-Turns, Inc., Louisville, Kentucky. Pike will be district manager for Tube-Turns and will promote this company's line of fittings for pipe welding and forged-steel flanges in the West Coast territory. Headquarters will be maintained in Los Angeles, California.

T. H. PIKE, JR.

J. R. BUTLER, formerly with the Ohio Oil Company, has been chosen manager of the coöperative recycling project of Cotton Valley, Louisiana, operators. An advisory committee to act in conjunction with the operators' committee consists of **W. F. DALTON,** Hunt Oil Company; **ROY DAVIS,** North American Oil Consolidated, Inc., and **HOWARD DAVENPORT,** Woodley Petroleum Company.

GEORGE J. CHURCHILL, general superintendent of drilling and production for the Arrow Drilling Company, now has his headquarters in Fort Worth, Texas. He has been working out of Odessa.

R. C. QUINN, superintendent in the Rodessa, Louisiana, field for Phillips Petroleum Company, has been transferred to El Dorado, Arkansas.

POWELL A. DENNIE, engineer, has been transferred from Oxford, Kansas, to Wichita, Kansas, by the Shell Oil Company, Inc.

J. L. LeBLEU has succeeded **E. W. POTTER** as superintendent of Cosden Petroleum Corporation's Big Spring, Texas, refinery. He has been assistant superintendent of the plant. Potter had been with the company 11 years when he resigned.

JESS ROGERS, Midland, Texas, district geologist for The Texas Company, has been transferred to Pampa, Texas, where he replaces **BEN PILCHER.** The latter has been transferred to Fort Worth.

M. T. FAIRCHILD has been appointed assistant superintendent of the Ponca City, Oklahoma, district of the Empire Pipe Line Company to succeed **J. W. FAGAN,** who has been transferred to Illinois. Fairchild has been at Bartlesville, Oklahoma.

JACK BARCKLOW, Wichita Falls, Texas, in charge of the North Texas district geological office for Deep Rock Oil Corporation, has resigned to take a position with Lane-Wells Company in their Oklahoma City, Oklahoma, office.

J. D. DAVIS has been appointed district manager of United Gas Pipe Line Company at Jackson, Mississippi, to succeed **J. P. ROGERS,** who died September 17, according to an announcement by **N. C. McGOWEN,** president.

Davis has served as Jackson district pipe line superintendent for the last eight years. He entered the service of one of the United's predecessor companies in 1924 as a timekeeper, advancing to district foreman at Beaumont, Texas, in 1930. He was made section foreman at Nederland, Texas, in 1932, and in the same year was transferred to the Jackson district of the company.

What have you accomplished if you are not sure the surveying records placed before you are accurate? How much time—how much money is involved? Does it pay you to buy anything but the best?

You Always Get What You Pay For!

That applies to well surveying services, too. There is always an **important reason** for ordering a survey—hence, it will pay you to use nothing but the best and most reliable service.

Sperry-Sun's SURWEL GYROSCOPIC Surveying Service renders an accurate, reliable, permanent and double checked record of the course of the hole to any depth. **It's the only service which by its double in — and out — survey guarantees that you cannot get a false record.**

SPERRY-SUN WELL SURVEYING CO., 1608 WALNUT ST., PHILA., PA.

SHAWNEE, OKLA. HOUSTON, TEXAS LAFAYETTE, LA. LONG BEACH, CALIF.
CORPUS CHRISTI, TEXAS SEAGRAVES, TEXAS BAKERSFIELD, CALIF.

C. K. STILLWAGON, president of Well Equipment Manufacturing Corporation, returned to Houston, Texas, late in September from an extensive tour through the north and east, including calls at Chicago, Illinois; Midland, Michigan; Buffalo, New York; Detroit, Michigan; Boston, Massachusetts; New York City, and Pittsburgh, Pennsylvania. He was accompanied on the trip by **MRS. STILLWAGON,** and also met **E. L. OLIVER,** North Texas district manager for Weco, in Chicago. The trip was made by automobile through the Eastern and New England States as far as Pittsburgh, from which point Mr. and Mrs. Stillwagon returned to Houston by train.

AUSTIN ALLEN, JR., has been named chief production engineer by Phillips Petroleum Company, Bartlesville, Oklahoma, to succeed **O. L. CARSON,** resigned. Allen has been assistant division superintendent in West Texas, Texas Panhandle, and New Mexico, making his headquarters at Amarillo, Texas.

J. C. B. VAN DEN BERG, equipment engineer of De Bataafsche Petroleum Maatschappij, has arrived in Houston, Texas, where he will maintain an office in the Shell Building. He will act as liaison engineer for the B.P.M. with respect to new developments in drilling and production equipment and methods.

THOMAS H. RISK, for the last five years with the Pure Oil Company, has joined Ethyl Gasoline Corporation in the Refinery Technology Division, it has been announced by **WILLIAM H. HUBNER,** in charge of that division. Risk will extend the technical service offered to Ethyl's refinery licensees through contact with refiners, and will assist in coördinating automotive research activities at Ethyl's Detroit and San Bernardino engineering laboratories with trends in refinery procedures. Prior to joining Pure Oil Company as automotive engineer in 1935, Risk was with Socony-Vacuum Oil Company in the Paulsboro laboratories.

ROSS BREWER, manager in Texas and New Mexico for the Texas Consolidated Oil Company, has changed his headquarters from Midland to San Angelo, Texas.

C. F. SELLERS, geologist for Robert H. Ray, Inc., has been transferred from Houston, Texas, to Laurel, Mississippi.

S. X. WILLARD, formerly sales manager of Econo-Vent Corporation, Chicago, Illinois, has become associated with Graver Tank and Manufacturing Company, Inc., East Chicago, Indiana, in the capacity of conservation engineer. Willard has been actively associated with the oil industry for the last 25 years, and at one time was engaged in the wholesale marketing of petroleum products in the middle west and purchasing of crude oil on the west coast.

In his new connection, Willard will devote his time to the introduction and sale of conservation equipment, developed by Graver after extensive research and study of petroleum problems, and will make his headquarters at the company's Chicago office, 332 South Michigan Avenue.

J. T. SUTLIFF is now in charge of the Chicago office of Roots-Connersville Blower Corporation, Connersville, Indiana. Sutliff, who succeeds the late **WM. TOWNSEND,** has been connected with Roots-Connersville for many years, and prior to going to Chicago in 1935 was at the Connersville factory. **E. A. COONS,** also a graduate engineer, has been placed in the Chicago office to assist Sutliff.

JOHN R. EVANS, Tulsa, Oklahoma, chief petroleum engineer for Stanolind Oil and Gas Company, recently was elected president of the Technical Club of Oklahoma.

DR. CLAUDE L. CLARK, formerly of the Department of Engineering Research of the University of Michigan, has joined the metallurgical staff of the Steel and Tube Division of The Timken Roller Bearing Company at Canton, Ohio, as metallurgical development engineer.

R. T. GERMAN, Odessa, Texas, field superintendent for the Magnolia Petroleum Company, has been made assistant to **JOSEPH KILCHENSTEIN,** superintendent of the Texas-New Mexico division, and transferred to Dallas. **C. E. TAYLOR,** lease foreman, succeeds German.

LA MAR JONES, petroleum engineer for Humble Oil and Refining Company, died in a Houston, Texas, hospital recently as the result of injuries received in a car accident.

J. E. WHEATLEY, district superintendent at Lovell Lake, Texas, for Humble Oil and Refining Company, recently was transferred to the Galveston Bay district, being succeeded at Lovell Lake by **C. H. KEEN.**

M. P. HUNTINGTON, division engineer at Casper, Wyoming, for the Stanolind Oil and Gas Company, has been made assistant field superintendent at Salt Creek and will have his headquarters at Midwest, Wyoming. **R. B. HAMILTON,** formerly field superintendent at Midwest, has been appointed district superintendent, and **C. E. JOHNSON,** who has been Hamilton's assistant, has been made field superintendent at Salt Creek.

J. H. GWIN, of Gwin Drilling Company, has transferred his headquarters from Centralia, Illinois, to Evansville, Indiana.

C. L. WHITEMAN, engineer for The Texas Company, has been transferred from Newton, Mississippi, to New Martinsville, West Virginia.

GILBERTO DELGADO, engineer with Carter Oil Company, is now making his headquarters at Altamont, Illinois, until recently having been at Fairfax, Oklahoma.

E. V. WINTERS, chief geologist, **ARTHUR R. MAY,** geologist, and **FRANK ITTNER,** seismologist, are members of a geological party sent to New Zealand recently by Superior Oil Company of Los Angeles, California.

RAY HUNT recently resigned as geologist for the Michigan Devonian Corporation and has opened a consulting office in Grand Rapids, Michigan.

HARVEY WILSON, formerly in charge of the Philadelphia, Pennsylvania, sales office of The Babcock and Wilcox Tube Company, has been transferred to New York City and placed in charge of the company's New York office territory as district sales manager. He will also have jurisdiction over the Philadelphia sales office, to which office **R. M. LACKNER** has been transferred from the Detroit sales office. **B. F. W. SEABURN** has been placed in charge of the Detroit sales office, having been transferred from the district sales office at Beaver Falls, Pennsylvania.

T. C. WEBB, JR., of the Technical Service Department of Clark Bros. Company, Inc., has recently been appointed program chairman by the Mid-Continent Section of the American Society of Mechanical Engineers. Webb has been with Clark Bros. for the last three years. A few months were spent at the company's factory at Olean, New York, since which time he has been stationed at the company's Tulsa, Oklahoma, office.

PRODUCTION BLOCKED BY A SLUG OF WATER

A Case Story

SOLVED WITH PREVENTIVE MAINTENANCE

TOMORROW—hundreds of plants may face a case like this: A midwestern manufacturer was suddenly swamped with orders. The plant had a good reserve capacity—yet, push as the management did, it failed to get the output needed.

The boilers and machinery were in excellent shape—but the steam lines were sluggish. The ailment was a common one—a condition that's quickly corrected with proper equipment.

That's how Preventive Maintenance entered the case. For, it's the only sure way of solving piping problems and keeping them solved. This simple technique guides you in installing and caring for pipe lines correctly; it helps you choose the right valves and fittings for every service.

This case shows how Preventive Maintenance works. While the management raved, the Superintendent put his hands on the trouble. The machines were not only slow in heating up, but they wouldn't stay hot. The drainage system was inefficient—it failed to remove condensate rapidly enough to keep the machines at maximum temperature.

The backlog of orders haunted the Superintendent. He saw that more than ordinary maintenance was necessary. "The Crane man," he said as he reached for a phone, "will help us solve this quickly and surely."

The two men reviewed the situation. To run the machines at top speed meant keeping them at maximum temperature. Condensate would have to be drained as rapidly as it formed. The correct solution, as Preventive Maintenance counseled, involved redesigning of the drainage system, and installing a Crane Inverted Float Trap on each machine.

Results: The condensate trouble was banished. Production was immediately doubled. Another user of piping knows the value of Preventive Maintenance. Also, knows that the best way to get most from piping maintenance dollars is to call in the Crane Man. Because, backed by Crane experience and the great Crane line of valves and fittings, he offers the means of a successful Preventive Maintenance program.

This case comes from the personal experience of W.F.C. —a Crane Representative in the Kansas City Branch

YOUR STEAM LINES KEPT HOT AND DRY WITH CRANE TRAPS

You are not getting the maximum heat and power from steam if your lines are not properly drained. You are straining the piping, shortening the life of valves, exposing steam-operated equipment to serious damage when condensate is not removed.

In steam lines up to 600 pounds pressure, the wasteful and damaging effects of condensate are completely eliminated with Crane Inverted Open Float Steam Traps. These sturdy, simple, and low-cost traps will pay for themselves many times over. Once installed they require minimum attention—yet, automatically, stop steam waste, step up efficiency.

For pressures up to 200 pounds, the Crane line of No. 981 traps will give maximum protection against condensate troubles.

1940 our 85th YEAR

CRANE

CRANE CO., GENERAL OFFICES: 836 S. MICHIGAN AVE., CHICAGO

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

LAUGH WITH BARNEY

Thrift

Bride: I saved $2.19 out of the week's allowance this week.

Groom: That's splendid. How did you do it?

Bride: One of the installment collectors didn't show up.

✦ ✦ ✦

The Reverend George Washington Hepzibah told his Deacons that he wanted every member of his colored flock to be present Sunday. "Sum-'body done stole mah ovahcoat. Ah's gonna burn dey ears down. Ennybody ain't present is guilty."

Everyone was there—even down to Moze, the log turner. The Reverend started off with a bang—preached on "Thou Shalt Not Steal," "Thou Shalt Not Kill"—really burned them down to a crisp . . . suddenly, a lull, and then he changed to one of the sweetest sermons he had ever preached. His flock left puzzled. Deacon Brown went back and asked the Reverend why he changed so suddenly about someone stealing his overcoat. The Reverend said, " 'Member about dat 'Thou Shalt Not Steal'? 'Member 'bout dat 'Thou Shalt Not Kill,' well when ah got down to dat Commandment 'bout Coveting Thy Neighbor's Wife, ah 'membered where mah overcoat wuz!"

✦ ✦ ✦

In the days of Queen Elizabeth some of the ladies of the court liked to curl up with a good book, while others preferred simply to curl up with one of the pages.

✦ ✦ ✦

Sign of Good Memory: When dad is worried because his daughter has stayed out too late with a boy friend.

✦ ✦ ✦

At the Old Manse

The minister had given out a story in advance.
The bride and groom about to be, would dwell within the manse.
The building so replete with charm, an ivy covered manse,
Prepared for clergyman and wife, was full of sweet romance.
But when the printer set the type, he busted up the plans.
And this is what the public read: "They'll live at the old man's."

✦ ✦ ✦

And then there was the man who had his dog's tail cut off so his mother-in-law wouldn't know that the dog was glad to see her.

Two army officers met on the street one day and one of the chaps had a row of medals across his chest. The other one remarked: "Where did you get all of those?"

"Gunnery."

"The hell you say. Why, I had it three years ago but I never got decorated."

✦ ✦ ✦

From Clark University has come the report of an artificial propagation of a rabbit, which just about takes all the fun out of being a rabbit.

✦ ✦ ✦

Cannibal King: What am I having for lunch?

Cook: Two old maids.

Cannibal King: Ugh! Leftovers again!

✦ ✦ ✦

Old Lady: Are you a little boy or a little girl?

Child: What the heck else would I be?

✦ ✦ ✦

"Do your daughters live at home with you?"

"Goodness, no. They aren't even married yet."

✦ ✦ ✦

A wildcat operator who was always talking in terms of thousands of dollars, was greeted one evening by his 11-year-old son, who announced:

"Well, Dad, I've sold our dog."

"Yes, for how much?"

"Ten thousand dollars."

"Ten thousand dollars! Let's see the money!"

"I didn't get the money, Dad," replied the son, "I got two five-thousand-dollar cats for it."

—*Rig and Reel.*

✦ ✦ ✦

Mose sat on his front porch munching cornbread when one of his hens went tearing past, followed by the old rooster in high gear. Suddenly the rooster applies his brakes, pulls up short, trots back and starts picking at the cornbread crumbs at Mose's feet. The old darky eyes him in astonishment then explodes, "Lan' sakes, Mr. Rooster, I hopes Ah never gets dat hungry!"

✦ ✦ ✦

Waiter: Customer says his steak is too small.

Manager: Take it away and bring it back on a smaller plate.

A mother was telling her little girl about the suffering of early martyrs and to illustrate the story showed her some pictures of scenes in the Roman arena where Christians were being fed to the lions.

Pretty soon the little girl burst into tears. The mother felt sure she had made a lasting impression on the child until between sobs she said:

"Look, mother, there is one poor lion without any Christian."

✦ ✦ ✦

A tourist stopped his car on the road and asked a little country boy how far it was to Smithville. The little boy replied: "It's 24,999 miles the way you're going, but if you turn around it ain't but four."

✦ ✦ ✦

Wife: The new maid has burned the bacon and eggs, darling. Wouldn't you be satisfied with a couple of kisses for breakfast?

Husband: Sure, bring her in.

✦ ✦ ✦

First Partner: The new stenographer's hair is decided blond, isn't it?

Second Partner: Yes, though I noticed a slight indecision around the roots.

✦ ✦ ✦

The golfer lost his ball and, not unnaturally, was inclined to be annoyed with his caddy.

"Why didn't you watch where it went?" he asked.

"Well, sir," said the boy, "It don't usually go anywhere, and so it took me unprepared like."

✦ ✦ ✦

Visitor: If your mother gave you a large apple and a small one and told you to divide with your brother, which apple would you give him?

Johnny: D'ye mean my big brother or my little one?

—*American Humorist.*

✦ ✦ ✦

Reformer: Young man, do you realize that you will never get anywhere by drinking?

Stewed: Ain't it the truth? I started home from this corner five times already!

✦ ✦ ✦

First Burglar: I need glasses.

Second Ditto: What makes you think so?

First Burglar: Well, I was twirling the knobs of a safe and a dance orchestra began to play.

3 GREAT "AMERICANS"

FOR EVERY OIL FIELD BEARING NEED!

MEDIUM, HEAVY DUTY AND SUPER HEAVY DUTY TYPES

For: Crown Blocks, Traveling Blocks, Draw Works, Clutches, Swivels, Rotaries, etc.

Three basic designs, in variations suited to every rig equipment need, make up the AMERICAN line of oil country Roller Bearings. Each one of these carefully engineered, field-proven, time-tested bearings, when properly applied, is guaranteed to give smooth, trouble-free performance under the most severe strains and impacts found in producing operations. Because they are built to *outlast* the equipment itself, few AMERICANS have ever failed in service! *Your* equipment *needs* AMERICANS . . . *your* Roller Bearing problems deserve the attention of American engineers. So be sure your new equipment is AMERICAN equipped . . . and use our engineering service freely when planning installations. Write today!

FULL ROLLER TYPE

For: Cross Heads (Slush Pumps, Engines), Piston Pins, Pumping Units, Sprockets, etc.

RADIAL TYPE

For: Rotaries, Swivels, Clutches, Draw Works, Transmissions, etc.

AMERICAN ROLLER BEARING COMPANY

PITTSBURGH PENNSYLVANIA

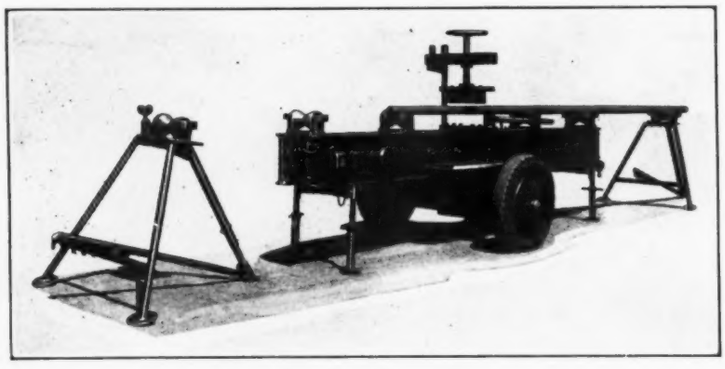
Pacific Coast Office: 321 West Pico Street, Los Angeles, Calif.

AMERICAN
HEAVY-DUTY ROLLER BEARINGS

MACHINERY and EQUIPMENT

Hydraulically Operated Pipe Straightener

A PORTABLE pipe straightener has been introduced by Shaffer Tool Works, Brea, California, to provide a means of straightening bent or kinked pipe at the well. The straightening device is hydraulically operated and the entire assembly embodies all the latest features of a strictly modern pipe straightening machine. The unit is mounted on springs attached to the axle and is equipped with a trailer hitch so it can be drawn by an ordinary small truck. The assembly is carried on automobile tires and its entire construction makes it easy to transport to and from different wells on a lease, or to wells scattered over a wide area, and for wildcat operations.

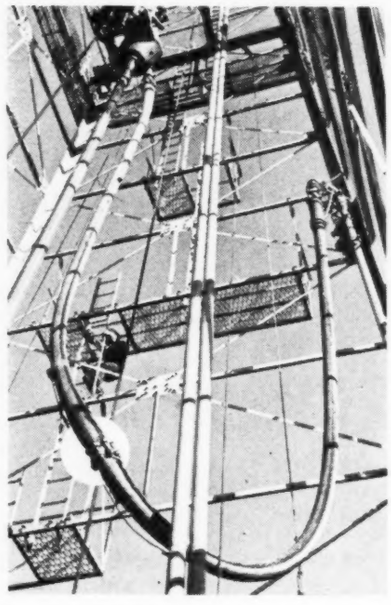


The Shaffer Portable Pipe Straightener is power-driven and is equipped with a ¾-hp. a-c. or d-c. reduction gear motor. Gasoline, gas, or butane motors can also be supplied if operating conditions make it necessary to utilize such power. The hydraulic power is supplied by an 8-in. diameter hydraulic ram actuated by a double piston pump having ¾-in. pistons and 4-in. stroke, operating at 125 r.p.m. The ram is controlled by a valve and when the pressure is released the return is made by heavy coil springs. Oil is used for fluid and is kept in a reservoir chamber. The oil supply is always ready for use and there is no loss of fluid during operations, it is stated.

The frame of the Shaffer Portable Pipe Straightener is constructed of two 15-in., 50-lb. I-beams, 15 ft. in length. An outstanding feature is that it is designed with a side opening on the ram bracket that makes it possible to roll pipe on and off the machine. This eliminates handling the pipe through the end only and is one of the many of its labor-saving features. Each end of the straightener is equipped with stationary, adjustable jacks that make it easy to level-up and hold the machine in a stable position without the use of wooden cribbing or other makeshift supports. Two portable roller stands are supplied, one for each end of the machine, and these are designed so that they can be raised or lowered to keep the pipe level throughout its length.

Hewitt Multiple-Length Rotary Hose

MANY rotary hose failures result from accidental injuries and abuse to the hose rather than from actual wear, and with the development of built-in couplings and longer hose lengths this problem becomes of greater importance because such couplings cannot be reset. A serious injury to hose at any point, even within a few feet of the coupling, means the replacement of 50 to 60 ft. of hose. After many months of drilling tests, Hewitt Rubber Corporation engineers have overcome this problem by developing a special, extra-strength built-in coupling construction that permits the use of two short lengths of hose—25 to 30 ft. each—rather than the one continuous length, it is asserted by the manufacturer. A hose failure, resulting from either wear or accident, with this multiple-length type of installation involves the replacement of only one piece—half the usual length.

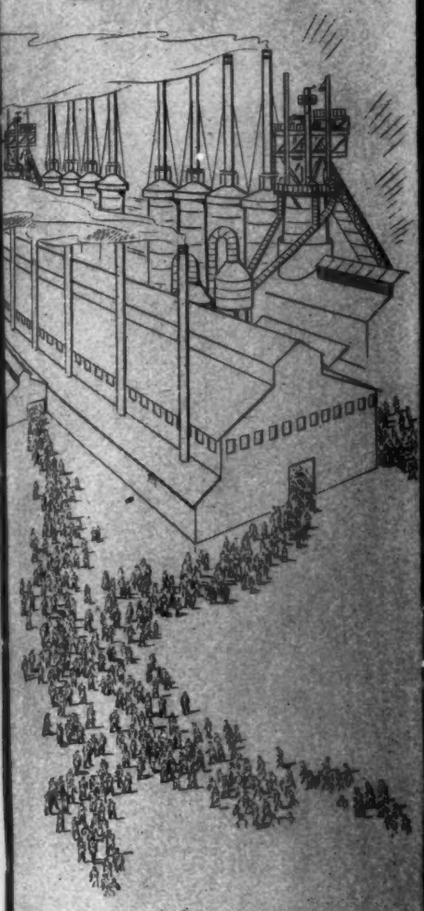


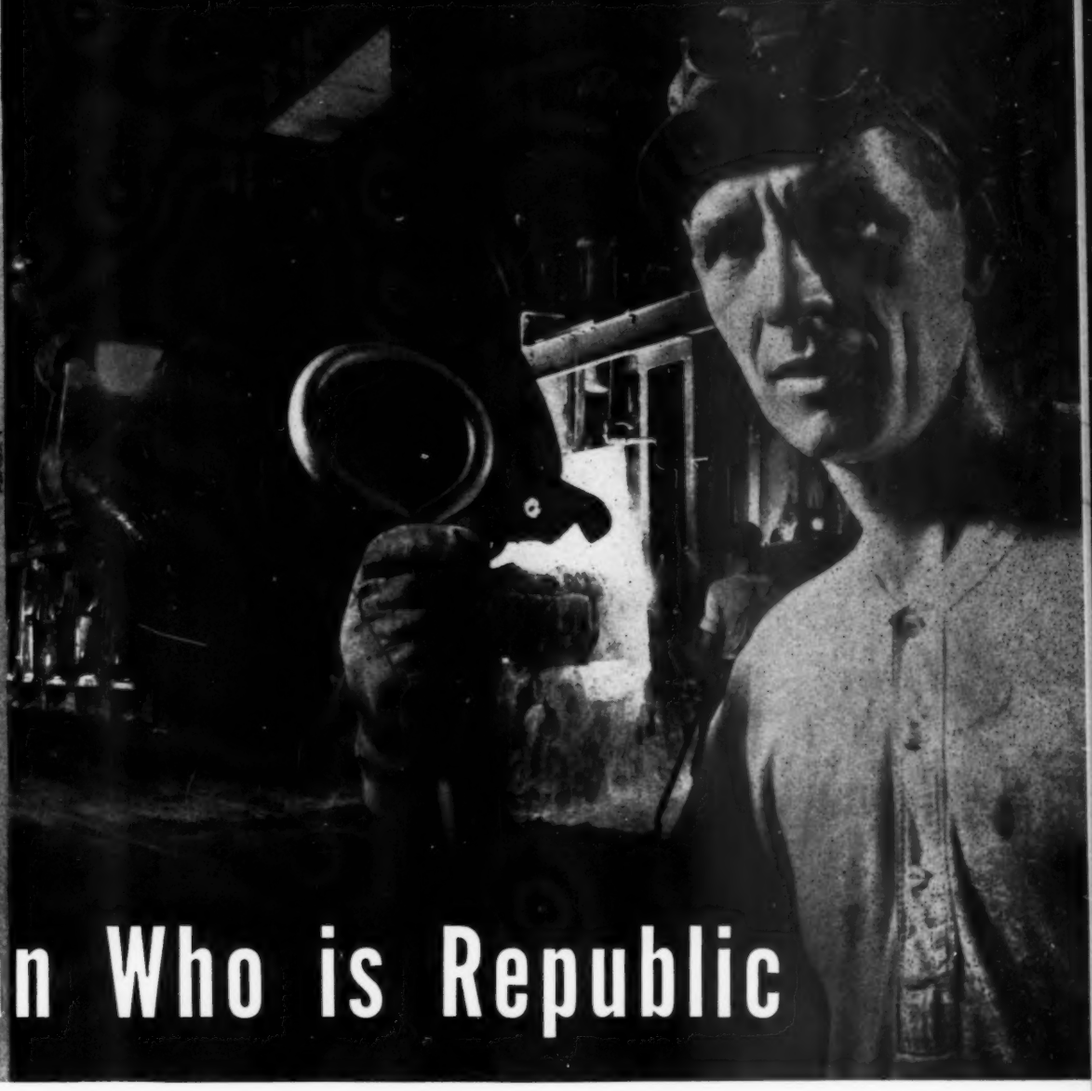
New Hewitt Multiple-Length Rotary Hose shown in the derrick of one Continental Oil Company well at Wasco field, California.

The couplings used in this new Hewitt hose are built into the hose wall, reinforced with multiple layers of high tensile spring steel wire securely clamped and bolted with steel bands. The entire inner surface of the coupling is rubber covered—the regular inner tube of the hose extending through the coupling shank and over the face. There is no metal exposed to wear and the inside diameter is the same as the rest of the hose, full sized with no flow-retarding obstructions.

The Hewitt Multiple-Length Rotary Hose is manufactured by Hewitt Rubber Corporation, Buffalo, New York.

Steel — FIRST LINE OF NATIONAL DEFENSE





The Man Who is Republic

No bugle wakes him from his morning sleep.

No uniform tells all who see him that he is defending the liberty of America.

No beribboned medal shows his work well done.

But there he is—a typical American—55,000 of him in round numbers—working in Republic plants, mines, offices and warehouses in 35 states—daily doing his share to turn out huge quantities of billets, bars and strips of steel—that every industry may have the sturdy raw material from which to fashion the sinews that will make America safe for his children—and yours.

This is the type of skilled-in-steel worker that mans the far-flung operations of Republic. This is the type of man that during peace-time brings comfort and safety to the American way of life. And this is the type of man who, in this emergency, is giving unstintingly of his effort and his specialized knowledge, to provide America with more and better ***steel—first line of national defense.***

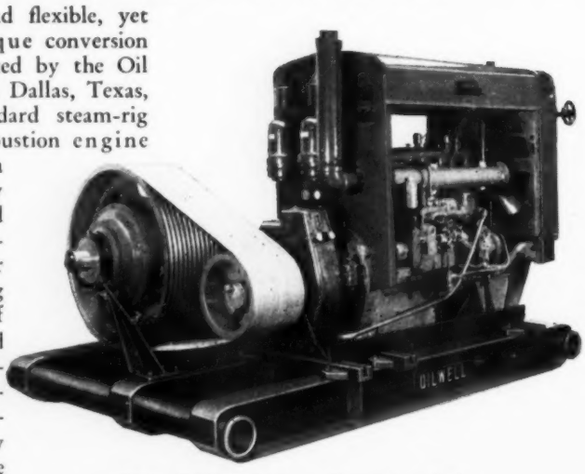
The line of steels and steel products manufactured by Republic is so diversified that we have prepared a complete listing in Booklet No. 199. A copy will be sent you upon request.

REPUBLIC STEEL CORPORATION • CLEVELAND, OHIO

Berger Manufacturing Division • Niles Steel Products Division • Steel and Tubes Division • Union Drawn Steel Division • Truscon Steel Company

"Oilwell" No. 4 Torque Conversion Unit

A POWERFUL and flexible, yet lightweight, torque conversion unit has been introduced by the Oil Well Supply Company, Dallas, Texas, for converting standard steam-rig hoists to internal-combustion engine drive. This unit fills a definite need in many fields where fuel and water are difficult to obtain, the manufacturer states. In rotary drilling operations to depths of 3000 to 4000 ft., and where the drilling program would not immediately justify the purchase of a complete new power hoist, this torque conversion unit permits the use of any standard two-speed steam-rig hoist with a conventional gas, gasoline or fuel-oil, multi-cylinder engine, it is pointed out.



"Oilwell" No. 4 Torque Conversion Unit

The engine torque is transmitted through a hydraulic torque converter, which also functions like a variable-speed mechanical transmission except that it makes available a multitude of ratios without the necessity of gear shifting. There is no mechanical connection, such as a friction clutch, between the engine and the output shaft of the converter.

A V-belt drive is used from the output shaft of the torque converter to the reversing countershaft. Forward and reverse rotation of the shaft are obtained by a friction clutch and also a planetary reverse, placed in the driven V-belt sheave. This leaves the shaft free for installation of a split-type drive sprocket, from which the hoist is driven by a standard oilfield chain. A split-type, flat-belt pulley may be installed to adapt the unit for cable-tool drilling.

The remote controls for this torque conversion unit are identical to steam engine controls in location and operation. In addition to the throttle, a hand lever is provided, having three positions corresponding to forward, reverse, and neutral. Drillers and crew do not have to learn a new set of operating characteristics as this unit handles exactly like a steam engine.

The performance of this torque conversion unit is unusual in that it is impossible to stall the engine when picking up a load or when making a hard pull, the makers assert. This is accomplished by the use of the hydraulic torque converter, which, on demand, multiplies the engine torque as much as five times.

Skinner-Seal Vented Plug Clamp

M. B. SKINNER Company, South Bend, Indiana, offers a new "Skinner-Seal Vented Plug Clamp" for use on extremely high-pressure pipe lines.

The pressure "vents" while the clamp is being placed in position, then the piston plug shuts off the leak as

easily, quickly, and positively as closing a valve, the manufacturer asserts. No chance of injury or damage.

The head of the clamp consists of a malleable iron cylinder resting on a pressure-distributing base. This is anchored to the pipe by bolts and strap. The cylinder is fitted with a rubber-faced metal "piston," operated by a heavy thrust screw; gasket surface is 2 3/16 in. in diameter.

To prevent "burning" of gasket in the last stages of shutting-off, the lower rim of the gasket is armored with a brass band. This also prevents rubber from escaping through the vent.

The bottom of the gasket is ground to fit the curvature of the pipe, and the piston is keyed in the cylinder to prevent rotating out of position while the thrust screw is being tightened.

Direct-Current Arc Welder By General Electric

THE General Electric Company, Schenectady, New York, has announced a new 200-amp., d-c. arc-welder that will provide any welding current from 25 to 250 amp. This wide range allows all-day manual welding to be done with currents to 200 amp., using electrodes from $\frac{1}{16}$ to $\frac{3}{16}$ in. in diameter. Capacity is also provided for the use of electrodes as large as $\frac{1}{4}$ in. on occasional short jobs.

The new arc-welder has two outstanding features, according to the manufacturer. First, it provides for in-

stant recovery of the voltage to an extent greater than the arc voltage after each short circuit, thus preventing time-wasting arc pop-outs. Second, it never allows current peaks to exceed three times the steady short-circuit current on any adjustment, thus preventing excessive heat and spatter and resulting in a saving of electrodes. Both features are made possible by a split-pole cross-field design with which the equipment is provided.

Other advantages of the new arc-welder include excellent commutation, isothermic overload protection for the motor, self excitation, which does away with the necessity for an extra generating unit; quick adjustment of welding current, and horizontal mounting, it is stated.

Self-sealed ball bearings are used. An improved, highly efficient ventilating system prevents overheating even when the welder is operated within the proper range hour after hour, it is asserted. A full range of current adjustment is obtained without the use of a current resistor. This results in a saving of 10 to 15 percent of power costs, according to the makers.

AXELSON COUPLINGS ARE BUILT FOR SATISFACTORY PERFORMANCE

Each coupling is placed on an accurately threaded mandrel and faces are ground square with the thread, reducing the possibility of fatigue strains to a minimum.

Axelson hardened and ground Sucker Rod Couplings are built to give longer, more satisfactory service. Axelson production methods are the result of more than 48 years experience in the building of oil well equipment. Every laboratory test, every manufacturing operation, every plant test has but one objective—namely, the production of sucker rod couplings that will satisfactorily meet every field requirement. Chemical and metallurgical tests are continually made in Axelson laboratories on coupling bar stock, the finished product and on couplings that actually have seen service. This meticulous care in selection of material, in manufacture and in service is why Axelson Couplings do wear longer and do establish new performance standards.

If you don't have a copy of Axelson's new sucker rod and coupling bulletin, write today.

AXELSON MANUFACTURING CO.

P. O. Box 98, Vernon Station, Los Angeles, Calif.
St. Louis New York Tulsa

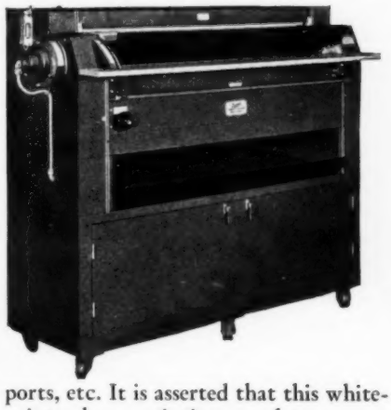
Bar stock specimens are acid etched to verify specifications and reveal any flaws which may exist in the raw materials.

AXELSON

SELLS AND SERVICES DEEP WELL PLUNGER PUMPS AND SUCKER RODS

Ozalid Model "F" Whiteprint Machine

OZALID Corporation, Johnson City, New York, announces a new Model "F" Whiteprint machine that, according to the makers, offers a fast, economical, convenient, and efficient method of making positive-type reproductions of engineering drawings, letters, charts, diagrams, bulletins, reports, etc. It is asserted that this whiteprinter has a printing speed to a maximum speed of 56-in. per minute. The light source used consists of a new type high-pressure mercury vapor lamp that uses 40 watts per inch with an active length of 46 in.



This lamp gives uniform distribution of light over the entire printing surface without flickering; gives no streaky prints and there are no globes or carbons to change. The Model "F" lamp is guaranteed for 1000 hours. Past performance indicates that this lamp has a life of between 1500 and 2500 hours, it is stated.

Other features of this equipment are:

1. Revolving glass contact that provides maximum light utilization and avoids slippage, friction, static, and dragging of paper and tracings across stationary glass.
2. An adjustable light shade that allows the operator to vary exposure without changing printing speed thus making it possible to handle prints efficiently and maintain a smooth flow of work despite variations in transparency of tracings.
3. A forced-air cooling system gives even cooling of the lamp so necessary for uniform light distribution. This cooling system effectively prevents high temperature differentials between right and left sides.
4. A special transformer that corrects the power factor to 87.5 percent. A terminal board on the transformer is equipped with taps permitting adjustments for line voltage variations from 200 to 240 volts. Thus correct voltage is assured for maximum lamp efficiency in each installation.

AXELSON LINERS STAND THE THIN AIR TEST

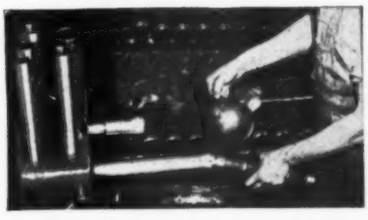
A steel ball that will pass freely through an Axelson Liner floats on air when one end of the liner is closed.

Stacked end on end, the faces of Axelson Liners are so true that the test made with one liner remains constant with the series. This is why Axelson Pumps with interchangeable liners are absolutely straight, practically air-tight and give maximum efficiency in plunger operation. Back of this accuracy is a never ending series of tests that cover everything even remotely connected with manufacturing—from molding sand to the final inspection and assembly—or packing of finished liner.

If you don't have a copy of Axelson's new liner bulletin, write today and a copy will be promptly sent to you.

AXELSON MANUFACTURING CO.

P. O. Box 98, Vernon Station, Los Angeles, Calif.
St. Louis New York Tulsa



The internal diameter of each liner is checked with "GO" and "NO GO" Gages to verify correctness of machine operations.

AXELSON

SELLS AND SERVICES DEEP WELL PLUNGER PUMPS AND SUCKER RODS

ON THE RECORD

HOSE C
4" Size
112,500 ft. of hole drilled

*Total Hose Cost
7/10c
Per ft. of hole drilled

*Includes purchase price and upkeep.

PERFORMANCE COUNTS

CHIKSAN *All-Steel* Rotary Hose is the most economical hose you can buy . . . Light in weight. Compare with other hose of the same size!

BUY THE HOSE THAT FITS YOUR PUMPS

4" and 5" for Drilling.
3" for Standby and Pressure Service.
45', 50', 55', 60' Lengths.

Gulf Engineers, Inc., Distributors in Texas, Louisiana, Arkansas and New Mexico.

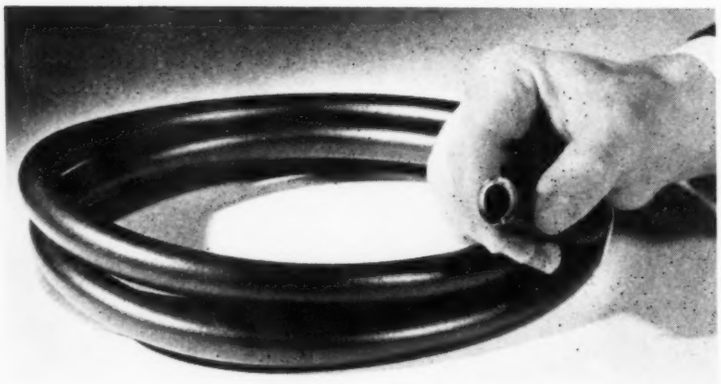
Well Equipment Mfg. Co., Distributors in Oklahoma and Kansas.

CHIKSAN BALL BEARING SWING JOINTS

CHIKSAN TOOL COMPANY
BREA, CALIFORNIA

BALL BEARING SWING JOINTS for ALL PURPOSES
ALL-STEEL ROTARY HOSE
CIRCULATING HEADS • MUD GUNS
THREE-WAY DISC BIT
STANDARD AND HEAVY DUTY REAMERS

Synthetic Tubing



A SPECIAL line of hose, or "tubing" for specialized, rigorous service where rubber has been found not entirely suitable is now being made from Koroseal, a synthetic elastic material having rubber-like qualities, it is announced by The B. F. Goodrich Company, Akron, Ohio. Koroseal is plasticized polyvinyl chloride, whose basic materials are coke, limestone, and salt.

The new Koroseal hose is made without fabric or other wall reinforcements and is being stocked in sizes ranging from ⅛ in. to ½ in. I.D., and 1/16 to ⅛ in. wall thickness and can be made at presetn in all sizes to 3 in. O.D.

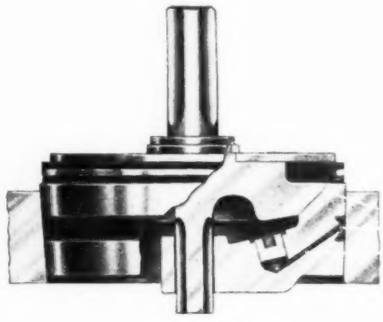
The hose shows durometer hardness, 70 to 78 at 85°F.; specific gravity, 1/31; working pressure, 50 lb. at temperatures to 120°F. It is made in dull black. Recommended working pressure of 50 lb. per sq. in. is based on a safety factor of 5.

Permitting no loss of vacuum through diffusion, the hose withstands vacuum better than equivalent wall thickness of rubber hose, the manufacturer asserts. It is free from sulphur, and can be attached to brass, silver, etc., without corrosion of the metal. It does not swell in oil, is not affected by strong corrosives, is practically impermeable to gas diffusion, and does not absorb moisture, it is stated.

Among the uses for the new hose are installations in chemical laboratories and plants, as slip-on coverings for plating rack insulation, in electrolytic ore reduction plants and other electro-chemical metal refineries, as friction roll coverings for business machines and recording instruments, and large photographic developing and printing plants.

Improved Slush Pump Valve Seat and Valve

A NEW line of slush pump valve seats and valves, designated the Hamer E-Z Out Valve Seats and Valves, has been placed on the market by Hamer Oil Tool Company, 2919 Gardenia Avenue, Long Beach, California. The new line, made for all



sizes and types of slush pumps, replaces the line formerly marketed under this name and has been under development in actual field use for the

last year or more.

The new valve seat is lifted from the pump port seat by hydraulic pressure alone, without the use of mechanical pullers or heating with a torch. A super-pressure grease gun, designed by Hamer Oil Tool Company, is used in lifting the valve. The valve seat is tapered in the usual manner but has an annular groove cut into its outside surface. A neoprene valve seat insert or packing ring is fitted into the groove with its lips contacting the upper and lower sides of the groove. A passage leads from the groove to a tapped hole in the central guide, which is integral with the valve seat. The tapped hole is closed by a screw plug at all times except when the super-pressure gun is to be attached for the purpose of lifting the valve seat.

Heavy-Duty, 20-Ton Emergency Jack

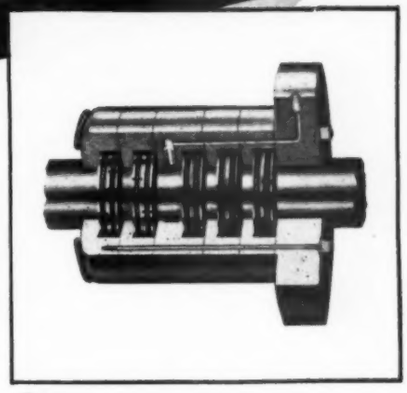
TO provide an emergency jack for use in the heavy industries, Templeton, Kenly and Company, Chicago, Illinois, have introduced a model that has a full 20-ton lifting and holding capacity on either the cap or toe lift of the jack.

Designated No. 2030, this jack is 30 in. high, has a full 17¾-in. lift, and weighs 167 lb. complete. Besides lifting on cap and toe, it lifts on the

auxiliary shoe that hooks into the cap or on the chain with grab hook end, any link of which can be engaged with the recess in the cap.

Besides lifting and lowering vertically, this jack tilts on its base for jacking at an angle. The tilting pawl can be released by the operator's toe. The No. 2030 can be used horizontally for pushing, spreading, or pulling by using the chain.

NOW non-scuff, double-quick seating
COOK'S PACKING RINGS
. . . they're TINIZED*



. . . which further reduces friction and prolongs rod and packing life . . .

* Patent applied for

THIS latest COOK development makes available for extreme service conditions, COOK'S Metallic Rod Packings fitted with COOK'S Graphitic Iron Packing Rings having **pre-conditioned** wearing surfaces.

This is the same "Tinized" surface treatment that has proved so successful on COOK'S Graphitic Iron Piston Rings. By a special electrical process the entire wearing surfaces of the packing rings are covered with a coating of a tin-base, anti-friction metal.

The benefits of these pre-conditioned wearing surfaces will be at once apparent to both designing and operating engineers—how they protect the rod from scuffing and undue wear during the break-in period—how they promote quicker "mating" of ring and rod surfaces—how they still further decrease friction and extend the life of both rod and packing to new limits.

COOK'S TINIZED Metallic Rod Packings offer you the utmost in packing performance and economy. Specify them next time you order equipment. For equipment in service, order from the nearest dealer or from us direct.

COOK'S METALLIC ROD PACKINGS are made in types for every engine and compressor rod service. In addition to the Graphitic Iron Packings the line includes COOKMET, Hard Babbitt and Laminated Bakelite Packings. We'll be glad to make packing recommendations for your particular requirements. Write us.

SEALING PRESSURES SINCE 1888

C. LEE COOK MANUFACTURING CO.
INCORPORATED
New York Cleveland Los Angeles Baltimore LOUISVILLE, KY. Chicago Tulsa New Orleans San Francisco

Emco Special Meter for Liquefied Petroleum Gases

A new meter, especially developed for the measurement of liquefied petroleum gases, has been announced by the Pittsburgh Equitable Meter Company. This meter has a cast-iron outer case, which the manufacturer states is necessary in order to assure complete safety in the measurement of these highly volatile vapors.

There are only two relatively short sealing surfaces in this design. It is asserted that by the use of surface grinding, a specially developed gasket, and a generous number of large-diameter screws, complete and permanent sealing is provided.

Of particular interest is the unit construction of the index housing within the meter cover. A new development in solderable, thick, high-strength glass provides a complete seal and eliminates the necessity of having a stuffing box to seal the index shaft.

Other innovations include a thoroughly lubricated and rigidly supported driveshaft mounted with its drive gear in an integrally designed movement box. This construction also provides a lubricated seal that prevents the escape of gas should the index glass be accidentally broken, it is stated.

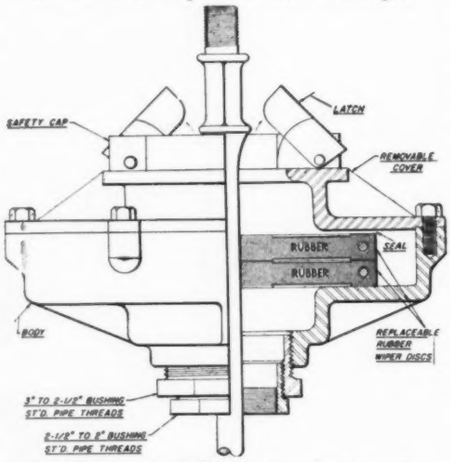
Optional diaphragms and diaphragm treatments are available. Either a special material, particularly resistant to the action of the liquid hydrocarbons, or sheepskin, with treatments adapted to resist this action, can be supplied.

Indexes reading in therms, decitherms, gallons, pounds, or equivalent cubic feet are available for specification by the purchaser. Special connections to fit the needs of the liquefied petroleum gas industry are provided optionally at the side or top of the cover.

The Pittsburgh Equitable Meter Company has issued a bulletin describing this meter in detail. Copies can be obtained by addressing a request to the manufacturer at 400 North Lexington Avenue, Pittsburgh, Pennsylvania.

Improved Sucker Rod Wiper

DESIGNED to accommodate all size sucker rods without change of rubber or housing, a Universal Sucker Rod Wiper has been developed



by Patterson-Ballagh Corporation. It operates in a manner similar to the pipe wiper or stripper made by the same manufacturers. Twin disks of reinforced rubber are held in a specially designed steel housing. These disks float freely in the housing, allowing the rods to move back and forth. The couplings on the rod pass freely through the disks, as does the pump or working barrel, without injury.

Replacement of the disks is a simple matter. The cover can be removed and disks renewed within a few moments. A pair of latches are provided that are closed except when the couplings pass through. Should the rod drop, these latches, by catching the couplings, will prevent their dropping into the well. An added advantage is the compactness of the Universal model, the manufacturer asserts. It has a height of less than 7 in. to the outlet. The device is universal in its fittings to fit the operator's pipe. A 2-in., 2½-in., and 3-in. standard pipe bushing assembly is included in the shipment, as is an initial set of wiping disks. Rods from ⅝ in. to 1¼ in., all on the same string, are effectively stripped with this wiper, it is stated. The pressure is sealed-off by contact of the disks with the inside surface of the cover. Excess oil is drained into the tubing.

Further details regarding this Universal Sucker Rod Wiper may be obtained from Patterson-Ballagh Corporation, 1900 East 65th Street, Los Angeles, California.

New Block and Pipe Insulation

A NEW 1500-deg. insulating material called L-W Superex has recently been introduced by Johns-Manville, New York City. Supplied in both block and pipe covering form, this new material was developed by the J-M Research Laboratories and represents a marked improvement in conductivity and strength for an insulation in the service temperature range above 600° F., according to the company's announcement.

This new insulation is of the moulded diatomaceous silica type, but it is exceptionally light in weight for a high temperature material, weighing only 20 lb. per cu. ft. The blocks are supplied in 3 in., 6 in., 9 in., and 12 in. widths in standard lengths of 18 in. and 36 in. and in thicknesses from 1 in. to 4 in. Curved blocks are also available. The pipe insulation is supplied, to fit standard pipe sizes, in sections of segments 3 ft. long and to 2½ in. thick. L-W Superex is marked with green ends to distinguish it from 85 percent magnesia and H-T (1900 deg.) Superex.

A.P.I. Specifications in Preparation

Specifications for rating roller-chain speed reducers for pumping machines adopted in November, 1939, are being published in tentative form by the Committee on the Standardization of Pumping Equipment and Engines of the American Petroleum Institute's Division of Production. Upon final approval the specifications will be published in booklet form as A.P.I. Standards No. 11-E-1, and will be available at 25 cents per copy from the Institute's Division of Production headquarters, 1205 Continental Building, Dallas, Texas.

MacClatchie Develops New Control Gate

A new combination high-pressure blowout preventer that features exceptionally fast and "foolproof" closing action has been announced by MacClatchie Manufacturing Company, Compton, California.

Consisting essentially of two packing units unitized in a single housing to conserve cellar space, reduce overall height, and eliminate need for extra flanges and threads, this tool packs-off around both drill pipe and open hole. Tests have shown it able to close-off around the pipe from drilling position in less than 25 seconds and completely shut-off the open hole in less than 10 seconds, the manufacturer asserts.

Another important feature of the new MacClatchie control gate is that there are no small gears or other working parts inside the housing to become clogged with mud or sand. All gears are on the outside of the unit, protected against damage by steel guards. This feature insures proper functioning of the packers in an emergency, it is stated.

Packing rubbers are available for various sizes of drill pipe. These rubbers can be installed at the rig in from 1 to 1½ hours, a feature that saves time and labor when changing from one size drilling string to another.

Complete details concerning this new MacClatchie development can be obtained by writing MacClatchie Manufacturing Company, Box 430, Compton, California.

Watchman's Tour System

A problem of growing importance to all industry is the need for effectively guarding property. This problem has been given more attention

currently because of the fears of sabotage, the uncertainty about fifth column operators, and the imperative need for protecting stocks of armament supplies.

The announcement therefore is timely that the Dudley Lock Corporation, Chicago, Illinois, has developed a new watchman's tour system adaptable to every size plant.

The Dudley tour comprises a system of key stations with transmitting stations at start and finish of each series. The transmitting stations can actuate any kind of signal or recording apparatus. A special recording clock has been made for the Dudley system by the Cincinnati Time Recorder Company. It records, on a long roll of paper, the date and the exact time each transmitting station is visited. An additional service is the delayed alarm, which gives a warning at any specified location when a transmitter box it not visited within a given time.

The watchman's tour key is small enough to be carried inconspicuously in the pocket. It is an ingenious combination of three separate locks, operating only on a predetermined route, and only in the proper sequence. It has a built-in cyclometer that counts the stations visited and thus gives proof of completion of a specified number of tours.

A CONTINENTAL
ON THE JOB

21 RED SEAL ENGINES FOR OIL FIELD SERVICE

for
STROUBE & STROUBE
at
TALCO, TEXAS

Look at these QUALITY FEATURES

1 Quick, push-button starting.
2 Individual porting (an exclusive patented Continental feature) which means smooth, balanced power.
3 Full length of cylinders surrounded by water for efficient cooling with jackets designed to eliminate hot spots.
4 Precision, interchangeable steel backed bearings.
5 Dust and dirt proof crankcase.
6 Cast iron base with extra large oil capacity available for all models.

This Sturdy Continental Red Seal PY-91, with 16.5 H.P. at 1400 RPM assures this operator of constant water supply

Red Seal Power is the right power for oil field service. Whether for spudding, drilling, pumping (from central power plant or individually) or generator service for power and lighting, write in your specifications — "To Be Powered by Continental."

There are 21 sizes of sturdy Red Seal engines to choose from. Just choose the right size for the job you want done and your power worries will be over.

For when you buy Continental Red Seal Power you buy power that is smooth, dependable, and economical. You buy the result of precise manufacturing. You buy the utmost in performance.

Available Sales and Service Facilities

ORIENTAL TRANSMISSION & PACKING CO.
2615 Commerce Street
DALLAS, TEXAS

STANDARD TOOL & MACHINE CO.
Longview, Texas

Continental Motors Corporation
MUSKEGON, MICHIGAN

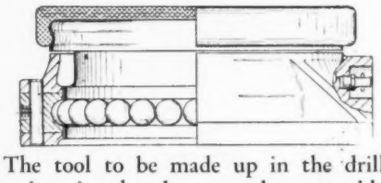
Spinning Table Aids in Making-Up Joints

A new device for use in making-up threaded connections of reamers, fishing tools, subs, bits, and other members in the drill string, designated the Baash-Ross Spinning Table, is announced by Baash-Ross Tool Company, 5512 Boyle Avenue, Los Angeles, California.

The spinning table fits in the square at the top of the master bushings in the same manner as a bit breaker or hole cover presents a rotatable surface upon which to rest the tool in a central position under the vertically hanging drill collar or drill pipe.

The spinning table consists of a square steel base having a ball race machined near the top on the inner surface and a circular table with a downwardly projecting flange of smaller diameter than the top of the table, also machined to form a ball race. Large-diameter balls, inserted through a small side opening after the base and table are together, form a bearing for retention and also hold the two parts together. The side opening is closed by a threaded plug.

In operation the Baash-Ross Spinning Table is placed in the square at the top of the master bushing, which places it concentrically over the hole.



The tool to be made up in the drill string is placed upon the rotatable table with the pin or box thread in line with the threaded connection of the drill collar or drill pipe hanging vertically in the elevators. As the drill collar or drill pipe is gradually lowered, a member of the crew rotates the tool upon the spinning table in order to start the thread. It is unnecessary to use chain tongs to rotate the tool upon the spinning table as the large lubricated bearing, formed by the balls and ball races, allows the table to turn freely. Also, it is unnecessary to rotate the drill collar or drill pipe in the elevators, as is often done when the tool is raised on the floor beside the rotary table, and the drill collar or pipe is pulled over at an angle while the joint is being made-up.

Complete information is contained in a bulletin that will be sent upon request.

10 YEARS' SERVICE AT 750° F. . . . AND STILL GOING STRONG . . . PROVES *HOMESTEADS* CAN "TAKE IT"!

Outstanding service in the well-known refinery above again demonstrates Homestead's ability to manufacture valves for specific purposes. 22 of these massive 8" 3-way valves went into switching valve service on vapor lines from coking chambers more than 10 years ago. Constant operation at 750° F. and 100 lbs. pressure, has proved their trouble-free operation and low maintenance cost. On the basis of their performance 10—4" Lever-Seald valves were installed on 1120° F. and 200 pounds pressure vapors to the coking chambers. Homestead takes real pride in mastering these hard-to-lick valve engineering problems. Tell us your service conditions, fluid to be handled, temperatures, pressure, and the number and size of valves required. Nearly 50 years of valve engineering guarantees a satisfactory and economical solution to your problem.

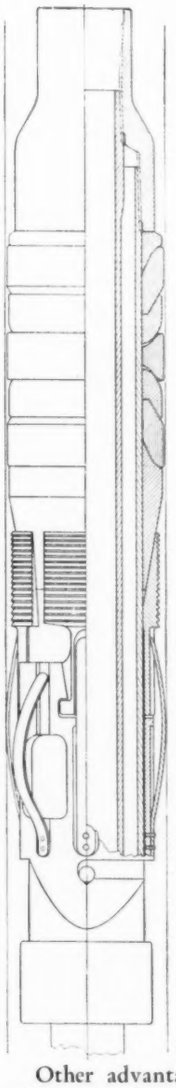
HOMESTEAD VALVE MFG. COMPANY
P. O. BOX 14 CORAOPOLIS, PA.

HOMESTEAD VALVES

Illustrated above: Special cast steel 8" three-way Homestead valves with two 4" straightway valves built integral with each 8" valve.

Write for Reference Book No. 38; and for special quantity prices on your valve requirements.

Kibele Combination Packer



A combination packer offering the advantage of both a pressure-packed and a mechanical seal is the latest tool put on the market by the Kibele Manufacturing Company, Dallas, Texas. By utilizing specially shaped neoprene cups reinforced with fabric as packing devices, the Kibele Combination Packer exposes the lips (see illustration) to gas or fluid pressure above or below the tool while the cups are being expanded and set by mechanical means.

Therefore, any increase in gas or fluid pressure, instead of trying to channel past the packings, only makes them seal more tightly, it is stated. This feature removes the necessity of resting the full load of the tubing on the packer in order to insure a seal under high pressure.

Other advantages of the combination packer listed by the Kibele Manufacturing Company are as follows:

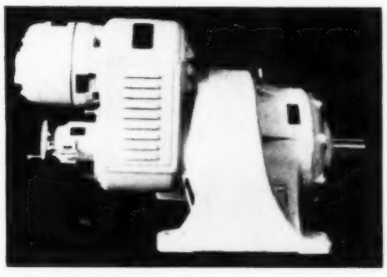
The short, compact construction of the cups, supported by metal bowls, minimizes the hazard of "freezing" to the casing.

The extra-long slips used in connection with the Type M Packer prevent wedging in the hole due to overloads and permit easy releasing and resetting.

Add to Line of Varidrive-Syncrogear Motors

TO provide more compact and smaller units, U. S. Electrical Motors, Inc., 200 East Slauson Avenue, Los Angeles, California, and 80 Thirty-fourth Street, Brooklyn, New York, has added the types VEV-GD and VEV-GT to its Varidrive line. These motors are of the Varidrive speed design with the double reduction and triple reduction gears for low-speed drives.

This new construction does not require a sub base to mount the Varidrive and Syncrogear as a unit and is consequently much lighter and more compact.



Further modification of the old design allows mounting of the Varidrive case at any angle with respect to the gear case. If the unit is to be mounted where head room is low, the Varidrive case may be laid over on its side or at any convenient angle.

The tooth surfaces of gears in all U. S. Syncrogear motors are hardened to 55/65 Scleroscope, providing a high standard of surface hardness.

Write for Syncrogear bulletin, U. S. Electrical Motors, Inc., Dept. 106, 80 Thirty-fourth Street, Brooklyn, New York.

Marking 50 years of service to the oil, gas and allied industries

The Fluor Corporation Ltd.

DESIGNERS · ENGINEERS · CONSTRUCTORS

Los Angeles · Tulsa · Kansas City · Houston · New York

Gas-Oil Ratio Equipment

ENGINEERING Laboratories, Inc., 610-624 East 4th Street, Tulsa, Oklahoma, announces new gas-oil ratio equipment, used to determine the amount of gas liberated from the oil under various conditions. Both flash and differential gas-oil ratios can be determined.

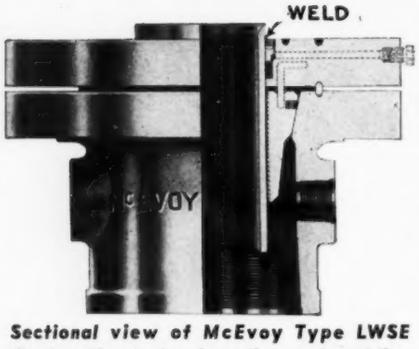
Low-pressure flash determination is made by realeasing saturated oil from the sampler into the gas-oil ratio equipment and measuring the following: (1) volume of gas, (2) volume of oil, (3) gravity of gas, and (4) gravity of oil. The volume of gas is measured by a wet test gas meter. The volume of oil is measured by the amount of mercury that is forced into the sampler from the mercury pump. A gravity bulb is used to obtain the gravity of the gas, and the gravity of the oil is determined with a hydrometer. This test is run with the relief valve set at 0 lb., 10 lb., and 20 lb. per sq. in. The gas released by this method is equivalent to that released between the well and the separator.

The high-pressure flash determination is made with oil and gas from the P-V cell after the pressure-volume relationship has been determined. The P-V cell is removed from the water bath and allowed to cool. The pressure in the P-V cell is then regulated to the desired amount with the mercury pump and the gas is released through the gas-oil ratio equipment. The gas is measured by the wet-test meter and the oil transferred to the burette and measured there. The gas released in this instance is equivalent to that released when the oil goes from the separator (held at this pressure) to the stock tanks.

The differential gas-oil ratio is determined by a new saturated sample placed in the P-V cell with the cell in a water bath at reservoir temperature. The pressure is reduced 200 lb. per sq. in. below saturation pressure and the gas bled off and measured. The oil left in the P-V cell is also measured. The new saturation pressure is determined, the pressure reduced 200 lb. per sq. in. below and the gas volume measured again. This procedure is followed until the pressure is reduced to approximately 500 lb. per sq. in. The determinations are then made at 400, 300, 200, 100, and 50 lb. per sq. in.

The saturation pressure is determined at 50 lb. per sq. in. and the mercury pump plunger retracted to allow gas space. The gas is then allowed to escape through the burette and the oil volume measured.

A Really ★★ SAFE
CASING HEAD for DEEP WELLS



Sectional view of McEvoy Type LWSE Casing Head showing slips and welding flange with hydraulic packing.

You are safe from costly leaks and casing failures when McEvoy Type LWSE Casing Heads support your long casing strings.

Casing is quickly and accurately set—Slips hold the casing at **exactly** the right tension. Weld and extra packing assures a positive seal. No time is lost in cutting spacing nipples—no more casing failures—you set every string quickly and safely with this casing head.

Perfect seal between strings—You test the seal **before** adding the next section. Pressure is applied between packing and weld to show up any leak.

Proved. Many of the longest strings in the world are supported by McEvoy Type LWSE Casing Heads. If you are starting a deep well be sure to try this trouble-saving casing head. Call McEvoy Company or your favorite supply store.

SEE McEvoy Section of 20 PAGES in the Composite Catalog

McEVOY COMPANY
TEXAS AT MILBY
HOUSTON, TEXAS
EXPORT OFFICE: 39 CHURCH ST., NEW YORK

A-C. Flex-Arc Welder

A NEW all-purpose portable a-c. welder designed for all-around general utility service and production welding of every type, has been announced by the Westinghouse Electric and Manufacturing Company. Standard models operate on either 220 or 440 volts, are completely self-contained, and incorporate several distinct new design features.

From 20 to 250 amp. of welding current is available in 27 current steps, with increments properly proportioned to meet the needs of welding with a wide variety of electrode types and

diameters, it is stated. Current adjustment is easy; just select the current desired, insert the bayonet plugs in the proper receptables and the machine is ready to weld. Current values are clearly indicated in large legible numerals.

Safety is well provided for. A built-in "De-Ion" breaker insures protection against long sustained overloads, such as might occur by accidentally leaving the machine short circuited, the manufacturer asserts. This is convenient, too, for disconnecting the machine from the line without having to go back to a service or feeder switch. Open circuit or striking voltage is exceptionally low, being on the order of 80 volts at 20 amp., and ranging to 50 volts at the highest current rating.

The welder is completely self-contained, being enclosed in a rugged steel case that is mounted on three wheels. Thus the machine is also portable. High efficiency, high power factor, and low no load losses insure maximum operating economies, the makers state. The welder is supplied complete with all accessories, including welding helmet with lens, electrode holder, all leads, and a 17-lb. assortment of electrodes. Both a three-pronged plug and receptacle for the power lead are included.

For further information write department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

Mud Pump Gauge For Oil Fields

ASHCROFT announces a new mud pump Duragauge for the oil fields. This new gauge is made with a fluid filled system and with a non-corrosive stainless steel bulb. No mud or water can get into the gauge mechanism.

It is easy to read and is made with a suppressed scale and open readings over the entire working range. The case is moisure-proof and dust-proof. It has a non-breakable front. It has a 2-in. male bottom connection for screwing directly on the pipe line. The heavy, steel bottom part may be removed for cleaning out, if necessary, without affecting the gauge itself.

It is not affected by vibration nor changes in temperature; it is as accurate in zero weather as at 100°F., the manufacturer asserts. Accuracy is guaranteed to within 1 percent of the scale range. Standard ranges are: 0 to 1500, 0 to 3000, and 0 to 5000 lb.

Further information will be supplied direct by the manufacturer: Ashcroft Gauge Division, Manning, Maxwell and Moore, Inc., Bridgeport, Connecticut.

WORLD'S MOST POPULAR TUBING TONGS

Now Allows User to "Put-On" and "Take-Off" ... or "Snap-On" and "Pull-Off"

PETOL was the first "snap-on" tong . . . the first tong made with a cam lever which locked the tongs on the pipe, making it possible to back-off the tubing and making it impossible for the tongs to fall off when being passed. These, and many other exclusive features found *only* in PETOL Tubing Tongs, have made it the fastest selling tongs in the world.

These valuable PETOL Tubing Tongs are now more outstanding than ever before, because *the same cam, which locks the jaws, also opens the jaws*, merely by pressing the cam lever against the handle. The user can now lay the tongs on the pipe, avoiding any possibility of creating a spark . . . yet this feature does not sacrifice the "snap-on" feature for those who want to use it. Furthermore, this opening feature greatly increases the life of the tong bits, and eliminates hammer action on the tubing.

For the convenience of users,* PETOL *Tubing Tongs are now made in Regular, Medium Heavy, Heavy Duty and Extra Heavy Duty sizes to match your job, regardless of tong strength required.

PETOL TOOLS TITAN TOOLS

GEARENCH MFG. COMPANY

HOUSTON, TEXAS, U.S.A.

EXPORT OFFICE: 74 TRINITY PLACE, NEW YORK, N. Y.

Redesigned Single-Cylinder Oil-Field Engines

A COMPLETELY redesigned line of single-cylinder, slow-speed type "Z" engines available in four sizes with cylinder displacements of 118, 208, 346, and 503 cu. in. has been announced by Fairbanks, Morse and Company, Chicago, Illinois. This new line, designated as the "ZC" engines, maintains all the outstanding features that made the old type "Z" engine popular in the oil industry for more than a generation, and, in addition, incorporates every worthwhile advantage applicable today, the manufacturer states.

These features include the adaptation of a vapor-phase cooling system to the engine, the use of renewable valve seats, oil-impregnated bronze bushed valve guides, roller bearings, controlled splash lubrication, and internally mounted governor operating in a bath of oil.

Of outstanding importance is the vapor-phase cooling system. A condensing radiator is mounted directly on top of the cylinder. Steam generated from the water expands into a special expansion chamber and enters the radiator. Air forced through the radiator by the cooling fan condenses this steam to water, which is returned to the system. Thus the temperature of the engine is held constant regardless of load or outside temperature and without the use of thermostats or

radiator covers, it is asserted. A vent prevents any formation of pressure or vacuum in the radiator.

The engine is completely oil tight. The cast-iron crankcase cover has unusually large gasket surfaces, and the roller bearings are sealed against oil leakage. In addition, any tendency for oil to leak out is prevented by carrying the crankcase under a slight vacuum through the use of a small breather valve operated by atmospheric pressure.

The enclosed governor permits an extremely wide speed range with very close regulation, and makes for desirable applications to all kinds of service. Piston speeds and rotative speeds are still maintained at very low rates, which insures long life and minimum maintenance expense, it is asserted.

The Fairbanks-Morse "ZC" engine is available in completely engineered combinations with electric generators, pumps of all types, compressors, etc.

On Pipeline Jobs Everywhere

"CLEVELANDS" DO IT -and STICK TO IT!

Aiming always at Perfection, not to "just get by" . . . pioneering sweeping advances in design . . . "CLEVELAND" has raised the level of performance, lowered both initial and upkeep costs of ditching-machines and allied equipment.

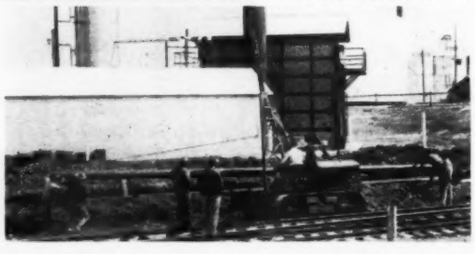
Generous-sized, field-equipped Diesel or Gasoline engines . . . large track area . . . wide tread . . . harder, stronger materials . . . all gears in grease-sealed housings . . . a preponderance of anti-friction bearings . . . "Multi-Speed" transmissions for individual, correct control of all speeds and feeds . . . weight well-balanced on fully-perfected, quick-maneuverable full-crawler mounting . . . quick, easy field servicing due to simple, accessible construction . . . rapid, cheap transportation . . . these are some of the reasons why "CLEVELANDS" are "tops" in real value. Two models illustrated below.

MODEL "140" DITCHER

Digs—16" to 30" wide 5'4", at speeds from ½ foot to 26 feet per minute. Spoil-conveyor shiftable and reversible. Extra strong boom, wheel and buckets. Digs all types of soil successfully. Operates over roughest terrain. Special equipment for stripping pipelines.

MODEL "90" BACKFILLER-PIPE CRANE

A pipeline backfiller that's built to go anywhere. Affords faster cleanup on any size line. Instantly available for lowering slack-loops, pulling road-crossings, unloading or laying pipe.



THE CLEVELAND TRENCHER COMPANY

"Pioneer of the Small Trencher"

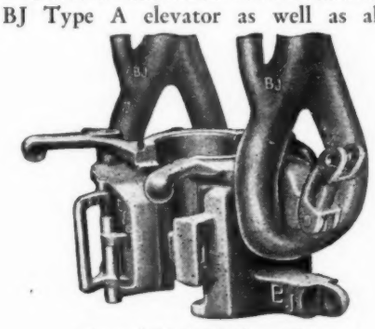
20100 ST. CLAIR AVENUE CLEVELAND, OHIO

Curved Link Block on BJ Elevators

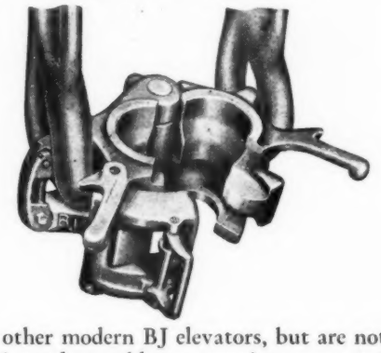
THE curved link blocks shown in the accompanying illustrations provide additional safety in retaining links under the elevator trunnions and permit greater freedom of movement of the elevator links when the elevator is being opened and closed, according to the manufacturer, Byron Jackson Company, Los Angeles, California. The link blocks are permanently hinged at the top, close downwardly, and are securely bolted in place. Thus, they provide a closed C-link that both

retains the elevators and increases the strength of the elevator trunnions.

The new link blocks are standard on BJ Type A elevator as well as all



Curved Link Block on BJ Type G Elevator; upper view open, lower view closed.

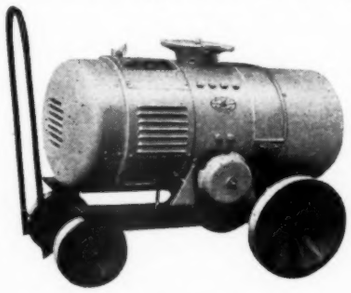


other modern BJ elevators, but are not interchangeable on previous types of elevators.

A catalog fully describing and illustrating these link blocks is available from Byron Jackson Company, P. O. Box 2017, Terminal Annex, Los Angeles, California.

Wilson Dual Voltage Switch for Arc-Welders

THE Wilson Welder and Metals Company, Inc., has announced a new dual voltage switch for installation on arc-welding machines, such as the Wilson "Hornet," when they must be used on either of 2 line voltages at different times. The new device, known as the Type CH Dual Voltage



Switch, can be used on any motor employing alternating current, provided the motor and starter are reconnectable for two voltages.

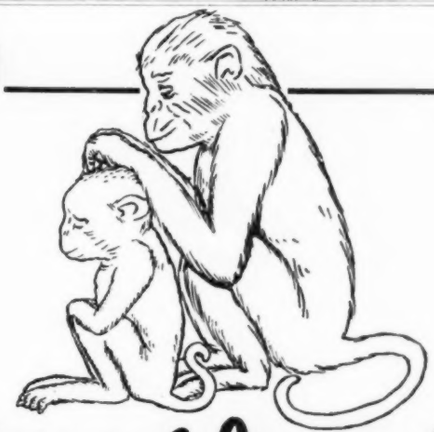
Normally, adjusting a motor so that it will operate at a different line voltage requires changing the heater elements, disconnecting and reconnecting the motor and magnet coil leads. This operation takes anywhere from ½ to 2 hours. With the switch installed, however, the change can be made in less than a minute.

The new dual voltage switch has two main parts: a base that is mounted directly on the machine, and a removable top cover that is held in place by a center stud and nut.

Adaptation of the dual voltage switch to different line voltages is simple and fast, the manufacturer asserts. The center nut is loosened and the top cover is rotated until the desired line voltage figures are visible. No other adjustment is needed. The switch can then be locked into position for safety.

The Standard Dual Voltage Switch is designed for 220-440 volts of a delta-connected motor—the type used on Wilson Welders. It reconnects the stator winding and also adjusts the holding coil of the magnetic starter and heater relays. Other connections, such as 220-440 volts of Y-connected motor and of Y-delta connection (380/220), all are readily obtainable.

Further information can be obtained from Wilson Welder and Metals Company, Inc., 60 East 42nd Street, New York City.



Careful Inspection!

From the standpoint of obtaining working information, it's vitally important that subsurface recording instruments be maintained in factory condition. It's logical that the men who have contributed to their design and who have been responsible for their manufacture can do a faster and more economical service job.

E.L.I. has exclusive rights to manufacture, sell, and service the Humble Type, **1¼" O.D. SUBSURFACE PRESSURE GAUGE,** designed to measure pressures within well bores, to an accuracy of 0.5%. **HIGH PRESSURE SUBSURFACE SAMPLERS,** designed to secure samples within well bores at predetermined depths and to retain them under pressure. **SUBSURFACE RECORDING THERMOMETERS,** for measuring and recording temperatures in fluid columns within well bores. Optional temperature ranges of 180° are available.

Write for Descriptive Bulletins and Prices on these and other special E. L. I. designed Instruments.

Engineering Laboratories, Inc.

CONSULTING ENGINEERS AND MANUFACTURERS

TULSA, OKLAHOMA, U. S. A.

Comprehensive Program Scheduled for Annual A. P. I. Meeting

A THOROUGH review of technological progress in every branch of the petroleum industry and a discussion of future problems and trends, coupled with comprehensive study of economic and other factors affecting the industry, are among the many features planned for the Twenty-first Annual Meeting of the American Petroleum Institute, to be held November 11 to 15 in the Stevens Hotel at Chicago, Illinois. The preliminary program follows:

Monday, November 11

Committee meetings all day.

Tuesday, November 12

Committee meetings all day.

GROUP SESSION

2:00 P.M. Automotive Transportation (South Ballroom)

Presiding: Leo Huff, The Pure Oil Co., Chicago, Ill.

Protection Against Static Electricity.

J. M. Pearson, Sun Oil Co., Philadelphia, Pa.

Preventing and Extinguishing Tank-Truck Fires.

J. F. Winchester, Standard Oil Co. of New Jersey, New York, N. Y.

Should Gross-Weight Limitations Be Universal?

J. W. Sinclair, Union Oil Co. of California, Los Angeles, Calif.

Safe Transportation in Oil Fields.

R. B. Roaper, Humble Oil and Refining Co., Houston, Texas.

2:30 P.M. Board of Directors' Meeting (Private Dining Room No. 1)

Wednesday, November 13

GROUP SESSION

9:30 A.M. Division of Production (South Ballroom)

Papers on the following subjects are now under consideration by the Program Committee. Speakers will be announced later:

Chemical Methods of Controlling the Gas-Oil Ratio in the Goldsmith Field of Ector County, Texas.

Factors that Should Be Considered in the Economic Aspects of Remedial Control of Water Production with Recovery of Oil.

Oil Recovery by Air Drive in the Venango Fields of Pennsylvania.

10:00 A.M. Board of Directors (Private Dining Room No. 1)

Board of Directors Luncheon at Noon

10:00 A.M. Board of Councillors Meeting (North Ballroom)

To nominate candidates for election as members of the Board of Directors.

GROUP SESSION

10:00 A. M. Division of Refining (Grand Ballroom)

Miscellaneous Topics:

Use of Lecithin in Gasoline.

W. S. Quimby, The Texas Co., New York, N.Y.

The Naphtha Polyform and Gas Reversion Processes.

J. E. Bogk, Phillips Petroleum Co., Bartlesville, Okla.
P. Ostergaard, Gulf Oil Corp., Pittsburgh, Pa.
E. R. Smoley, The Lummus Co., New York, N. Y.

Synthetic Chemicals from Petroleum.

L. Rosenstein, Shell Chemical Co., San Francisco, Calif.

The Use of Azeotropic Distillation in Separating Hydrocarbons from Petroleum.

Frederick D. Rossini, B. J. Mair, and A. R. Glasgow, Jr., National Bureau of Standards, Washington, D. C.

The Emulsion De-oiling Process.

A. H. Schutte, The Lummus Co., New York, N. Y.

GENERAL SESSION

2:00 P.M. (Grand Ballroom)

Presentation of accident-prevention certificate awards.

Report of Board of Councillors and election of Directors.

President's Address:

Axtell J. Byles, American Petroleum Institute, New York, N.Y.

Address:

T. H. Barton, Lion Oil Refining Co., El Dorado, Ark.

Address:

Speaker to be announced.

Thursday, November 14

GROUP SESSION

9:30 A.M. Division of Production (South Ballroom)

Papers on the following subjects are now under consideration by the Program Committee. Speakers will be announced later:

Engineering Analysis of Depth-Pressure-Potential Tests in California.

Definitions and Technique of Determining Factors Affecting Reservoir Performance.

Progress Report on Multi-liquid Studies — A.P.I. Research Project 37.

GROUP SESSION

9:30 A M. Division of Production (West Ballroom)

Pipe-Line Transportation Problems:

Presiding: J. C. Stirling, Stanolind Pipe Line Co., Tulsa, Okla.

Progress Report—Final Inspection of A.P.I. Pipe-Line Coating Tests.

K. H. Logan, National Bureau of Standards, Washington, D.C.

Fluid-Meter Research at the University of Oklahoma.

W. H. Carson, Dean, College of Engineering, University of Oklahoma, Norman, Okla.; and E. E. Ambrosius, associate professor of mechanical engineering, University of Oklahoma, Norman, Okla.

Thirty-Minute Movie—"Construction of Salt Lake City Pipe Line of Stanolind Pipe Line Company.

J. C. Stirling, Stanolind Pipe Line Co., Tulsa, Okla.

10:00 A.M. Board of Directors (Private Dining Room No. 1)

The Executive Committee will meet immediately following the last session of the Board of Directors.

GROUP SESSION

10:00 A.M. Division of Refining (Grand Ballroom)

Heavy-Duty Motor Oils.

H. C. Mougey, General Motors Corporation, Detroit, Mich.

Address:

W. S. James, The Studebaker Corporation, South Bend, Ind.

Illustrated Field Observations of Paint Performances and Practices at Refineries.

H. H. James, E. I. duPont de Nemours & Co., Tulsa, Okla.

GENERAL SESSION

2:00 P.M. (Grand Ballroom)

Address:

W. J. Cameron, Ford Motor Co., Detroit, Mich.

Address:

H. W. Prentis, Jr., National Association of Manufacturers, New York, N. Y.

Address:

Hon. Martin Dies, Member of Congress, Washington, D. C.

7:30 P. M. Annual Dinner (Grand Ballroom).

A program of entertainment is being arranged.

Friday, November 15

GROUP SESSION

10:00 A.M. Division of Production (South Ballroom)

Drilling Practice:

Papers on the following subjects are now under consideration by the Program Committee. Speakers will be announced later:

Continuous Logging at Rotary-Drilling Wells.

Hydraulics of Mud-Circulating Systems.

Report of Division's Nominating Committee.

A. H. Riney, Phillips Petroleum Co., Bartlesville, Okla., chairman.

Election of Twenty Members of the General Committee of the Division of Production.

GROUP SESSION

10:00 A.M. Division of Refining (Grand Ballroom)

Fuels and Engines:

Engine Performance as Influenced by Ignition-Timing Maintenance.

R. J. Greenshields and L. E. Hebl, Shell Oil Co., Inc., Wood River, Ill.

Fuel-Quality Requirements as Affected by Items of Engine Maintenance.

H. M. Trimble and K. C. Battenberg, Phillips Petroleum Co., Bartlesville, Okla.

Trends in Automotive Design Match Evolution in Fuels.

T. A. Boyd and W. G. Lovell, General Motors Corporation, Detroit, Mich.

Report of Division's Nominating Committee.

H. W. Camp, Cities Service Oil Co., Bartlesville, Okla., chairman.

Election of Twenty Members of the General Committee of the Division of Refining.

Fluor Corporation Celebrates Fiftieth Anniversary

The Fluor Corporation, Los Angeles, California, observed its 50th anniversary and celebrated moving into its new plant by holding open house on October 8.

Fifty-three years ago, at the age of 21, J. S. Fluor left the little village of Sass, Switzerland, to join his brothers in the construction business at Oshkosh, Wisconsin. He entered into a partnership with them in 1890 that continued until 1912, when he moved to California. He soon realized the possibilities offered an engineering and construction organization in the oil and gas industry and began the construction of cooling towers, compressor plants, gas scrubbers, mufflers, and ultimately, complete refineries and natural gasoline plants.

After 12 years of foundation development, The Fluor Corporation was incorporated in 1924, headed by J. S. Fluor, Sr., president; P. E. Fluor, executive vice-president and general manager; J. S. Fluor, Jr., vice-president and assistant general manager, and F. E. Fischer, secretary and treasurer.

The site of the new Fluor plant is at 2500 South Atlantic Boulevard, Los Angeles. Buildings actually constructed or in course of construction involve more than 60,000 sq. ft. of floor space. The new general offices occupy 10,000 sq. ft.

J. S. FLUOR, SR., President

Entrance to Administration Building

P. E. FLUOR, Executive Vice-President and General Manager

J. S. FLUOR, JR., Vice-President and Assistant General Manager

F. E. FISCHER
Secretary and Treasurer

H. R. LAMBERTH
Manager Cooling Tower Division

W. EARL DUNN, Vice-President and Manager Kansas City Division

Nomad Speaker Talks on Foreign Geophysical Work

One of the outstanding meetings of the Los Angeles Chapter of Nomads was held in Los Angeles, Wednesday evening, October 9. Charles Gill Morgan, a member of the chapter who has conducted a great deal of geophysical work in South America, was the speaker of the evening and described recent operations in Patagonia, northern Argentina, and Brazil. His talk was illustrated with motion pictures. Morgan, moreover, was a member of the second Byrd Expedition to Little America in the Antarctic and he then gave a most interesting talk on the work of the expedition. This was accompanied by slides that depicted the living conditions during the time Admiral Byrd and his party were in Little America.

Due to absence from the city of the president and vice-president, the business meeting was conducted by Bill Bettis and the dinner session was presided over by Earl Rees. Elmer Decker, national president of the Nomads, proposed that the chapter conduct classes in Spanish for the members as it is widely felt that a knowledge of and ability to speak that language will do much toward increasing the friendly relations with Latin Americans whom the Nomads contact in their trips to South America. He emphasized that there will be an ever-increasing demand for contact with Spanish-speaking people in the selling of oil equipment and that everyone traveling in South American countries should be able to speak the language. A committee was appointed to take this matter under consideration and make a report at the next meeting.

Among the guests at the Nomads' dinner were the following men from foreign fields: R. E. Curran of Burmah Oil Company; E. A. Kodyen of Papuan Anipiani Petroleum Company, Papua; E. M. Donovan of Burmah Oil Company at Digboi, Upper Assam; J. A. Thornton of B.P.M. at Curacao; M. H. Bush of Bahrein Petroleum Company; J. S. Aston of Ultramar, S.A.P.A.; H. J. Cleave of Caribbean Petroleum Company at Maracaibo; B. E. Ormsby of The Texas Company of Venezuela, and Phillippi Gordon of the Kern Trinidad Oilfields, Ltd.

Acquires Roots-Connersville Turbine Pump Division

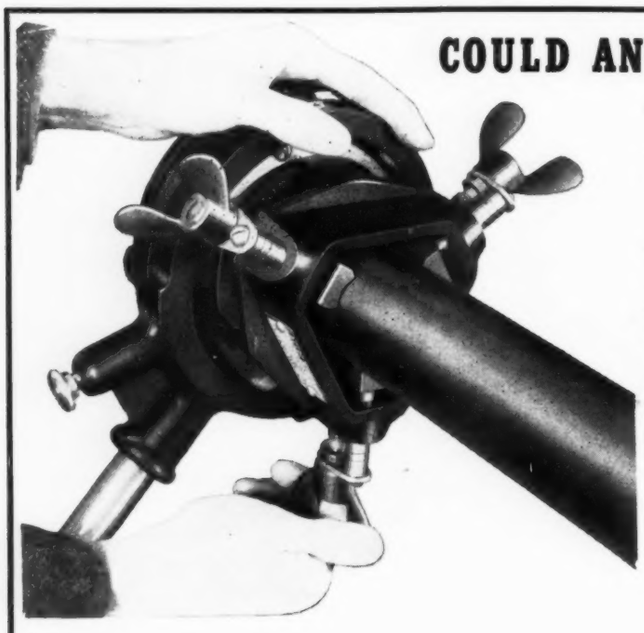
Sterling Pump Corporation, Hamilton, Ohio, has acquired the Turbine Pump Division of the Roots-Connersville Blower Corporation, Connersville, Indiana.

A transfer of inventory has already been made from Connersville, Indiana, to Hamilton, Ohio, according to Henry J. McKenzie, president of the Sterling Pump Corporation.

Automatic Control for Compressors Used for Refrigeration

In conjunction with H. C. Cooper, research engineer, and the Gas Machinery Company, Cleveland, Ohio, Clark Bros. Company, Inc., has developed an automatic control for gas engine compressors used to provide refrigeration for cooling natural gas that is being liquefied.

The initial installation of the new controllers was recently made on two Clark 600-hp. and one Clark 500-hp. angle-type compressors in the Cleveland storage plant of the East Ohio Gas Company. The controllers keep the refrigeration developed by the compressors in accurate step with the amount of gas being liquefied. These engines, which are the Clark supercharged 2-cycle type, were chosen for the most difficult service encountered in this latest development of the natural gas industry.



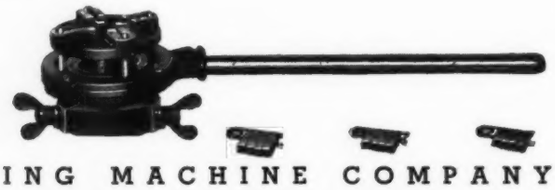
COULD ANYTHING BE MORE SIMPLE?
. . . YET BE AS ACCURATE

—as the work-holder on a "TOLEDO" No. 1BR 1" to 2" Ratchet Threader.

Three broad-faced chuck jaws accurately center and firmly hold the tool to the pipe—no cocking or wobbling. The threads are cut straight with the axis of the pipe assuring accurate alignment when pipe is assembled.

Four sets of dies — one for each size — assures smooth, standard taper threads and easier operation.

Complete details on request or order from your local distributor. You'll like the "TOLEDO" No. 1BR.

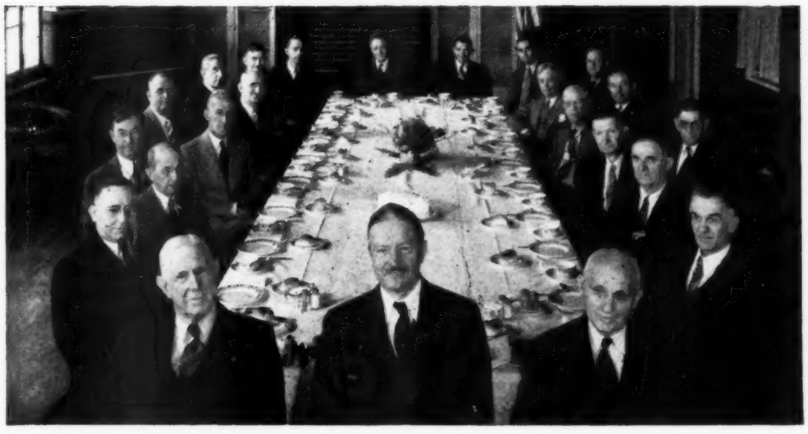


THE TOLEDO PIPE THREADING MACHINE COMPANY
TOLEDO, OHIO
NEW YORK OFFICE, 72 LAFAYETTE STREET

"TOLEDO"
TRADE-MARK REGISTERED

YOU'LL DO BETTER WITH A "TOLEDO"

Another Veteran Meter Maker Celebrates 50th Anniversary



In the foreground, left to right: Horace Chrisman, Colonel W. F. Rockwell, Joseph Klein

A luncheon was given recently at the Penn Lincoln Hotel, Wilkinsburg, Pennsylvania, in honor of Joseph Klein, a foreman of the Pittsburgh Equitable Meter Company's meter shop, who rounded out 50 years of continuous service for that company. Fellow employees and officials of the company made up the guest list. Among those who paid tribute to Klein were Colonel W. F. Rockwell, president of Pittsburgh Equitable, and Horace Chrisman, a veteran who completed 50 years of service two years ago. Klein was presented with a purse as a tribute for his service record.

McPeake Sales Manager "Oilwell's" Export Division

RICHARD H. McPEAKE

Richard H. McPeake has been appointed sales manager of Oil Well Supply Company's Export Division and will maintain his headquarters at 30 Rockefeller Plaza, New York City.

McPeake joined "Oilwell" in 1938 and prior to that spent eight years with oil companies in the United States and South America.

Look for the *Arm and Hammer*

ARMSTRONG BROS.

PIPE WRENCHES

CHAIN TONGS

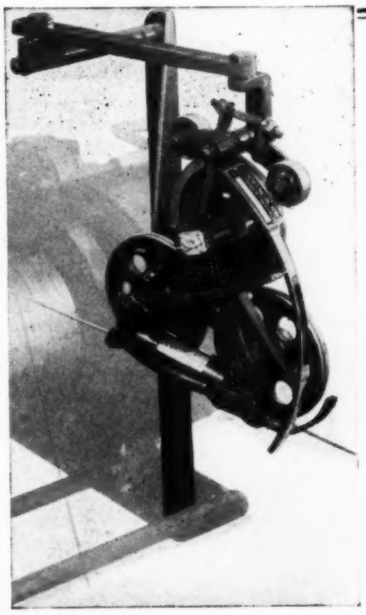
Jaws are drop forged from special steel, heat treated, hardened, tempered and tested. Handles forged from high carbon steel have both stiffness and "spring."

Flat Link Chains have proven strength —are proof-tested to 2/3 catalog strength (3,600 to 40,000 lbs.). Design improvements; jaws have increased bearing on bar and forged-in chain guides, large steel bolts, drop forged alloy steel shackle. Better PIPE TOOLS—the most complete line made and each an improved tool.

Solid Stock and Dies — **Pipe Cutter**
Adjustable Dies and Stocks — **Knife Blade Cutter Wheels**
Receding Threaders — **Pipe Wrenches**
Hinged Pipe Vises — **Chain Tongs**

Write for new C-39 catalog

Armstrong Bros. Tool Co.
"The Tool Holder People"
331 N. Francisco Ave., Chicago, U.S.A.
Eastern Warehouse and Sales
199 Lafayette Street New York



MATHEY Measure Meter and Weight Indicator

MEASURE METER and WEIGHT INDICATOR

The Type B Measure Meter and Weight Indicator is adaptable to all units using measure meters. It is built for any size measuring or torpedo line.

For any depth work, with reel capacities from 5,000 feet to 15,000 feet of .072 line. Seven models are available for mounting in trailers, cars, pulling-units, and core drills. Self-powered by gasoline engine or power take-off models.

MATHEY PORTABLE MEASURING UNITS

This new measuring device eliminates the factor of human error in well measuring operations, by indicating, on easily read dials, the weight and length of line in the hole.

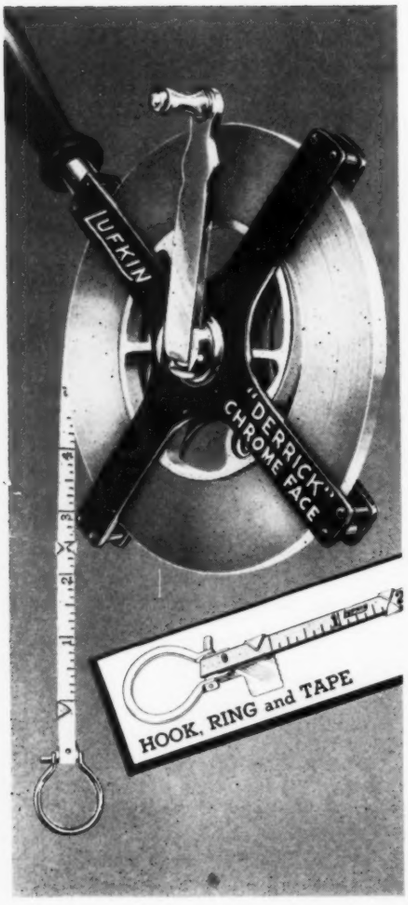
Write for Descriptive Literature

Gas Testing Equipment — Measuring Meters
Reeling Equipment for Well Shooting
Oxy-Acet Pipe Beveling Machines
Designers, Manufacturers of Special Machinery

WRITE FOR DETAILS

C. A. MATHEY MACHINE WORKS

Phone 3-3623 **212 South Frankfort** **Tulsa, Oklahoma**



"DERRICK" CHROME FACE

Now available with the new Chrome Face line, the Lufkin "Derrick" Steel Tape is more than ever the perfect tape for work in a derrick. It's easy to read even in dim or artificial light because of the jet black markings on the satin chrome surface. It's durable. The smooth surface won't rust, crack, chip or peel, is easy to clean and remarkably free of glare. The large end ring and hook aid in taking accurate measurements quickly. The ¼ inch line reduces wind resistance.

WRITE FOR FREE CATALOG

LUFKIN

SAGINAW, MICHIGAN · New York City

TAPES · RULES · PRECISION TOOLS

Dresser Acquires Pacific Pump Works

Of interest to the refining, producing, and pipe-line divisions of the oil industry is the announcement by the Dresser Manufacturing Company of their acquisition of the Pacific Pump Works. The Dresser Manufacturing Company is prominent throughout the oil industry, having been organized in 1880. It manufactures pipe couplings, sleeves, and repair devices for the construction and maintenance of pipe lines. Head office and plant are at Bradford, Pennsylvania.

A. R. WEIS

R. E. REIMER

Pacific Pump Works, established in Huntington Park in 1924, has become well-known by virtue of their manufacture of various types of centrifugal pumps for refineries and boiler feedwater plants. They also produce turbine pumps for water wells and deep-well plunger pumps for oil-field production.

Other subsidiaries of the Dresser organization include Clark Bros. Co., Inc., of Olean, New York, manufacturers of gas and Diesel engines and compressors, and The Bryant Heater Company of Cleveland, Ohio, manufacturers of gas heating and air-conditioning equipment.

Outside of changes announced in management personnel and directorate, the operations of the Pacific Pump Works will continue with no variation of company policy.

J. B. O'Connor, vice-president of Clark Bros. Co., Inc., will serve as chairman of the board of directors. A. R. Weis, formerly vice-president of Pacific Pump, was elected president of the California company, and R. E. Reimer, treasurer of Dresser, has been named the secretary-treasurer. Directors include J. B. O'Connor, A. R. Weis, H. N. Mallon, C. P. Clark, and R. E. Reimer.

M. G. McCool Made General Sales Manager American Iron Company

M. G. (Mac) McCool, district manager for the American Iron and Machine Works Company, in the West Texas-New Mexico territory for the last five years, has been appointed general sales manager of the organization with headquarters in Oklahoma City, Oklahoma. McCool has had a wide experience in the oil industry having spent several years with the major supply companies in various capacities. He also spent two years with the Standard Oil Company of Venezuela in South America in the purchasing and warehouse division. Before joining the American Iron and Machine Works Company, McCool was employed by the Phillips Petroleum Company, Bartlesville, Oklahoma.

Harry E. Nelson, plant superintendent of the company's Monahans, Texas, plant for the last five years has been advanced to the position of district manager over the West Texas-New Mexico territory. Nelson began with American in 1924 at Tonkawa, Oklahoma.

B. E. Fox, purchasing agent and office manager, has been advanced to the position of district manager over Oklahoma, North Texas, Illinois, California, and Wyoming. He will also be in charge of export sales. Fox became associated with this company in 1925, in Tonkawa, Oklahoma.

Varney S. Harlin, who has been in the engineering department for the last six years, has been advanced to the position of chief engineer and head of the development and experimental departments.

L. D. (Jiggs) Murray, district sales manager in Louisiana, has been advanced to the position of district manager of the Gulf Coast area. Murray will continue to make his headquarters in Houston, Texas.

Homco Extends Fishing Tool Service to California

R. E. "Red" Golemon

Homco Cutting and Fishing Tool Service, a division of Houston Oil Field Material Company, Houston, Texas, announces the inauguration of a cutting and fishing tool service, together with a side-wall sampling service, for California fields. Location has been established with the Valley Warehouse Service Company, Bakersfield, California. The personnel appointed for

E. E. Millican

D. U. Skinner

service in California includes R. E. "Red" Golemon, district superintendent, D. U. Skinner and E. E. Millican.

B. Bronzan Promoted

B. BRONZAN

B. Bronzan, sales manager of Baash-Ross Tool Company, has been given the additional post of assistant general manager, according to an announcement by L. F. Baash, president. His headquarters will continue to be at the Los Angeles office.

TAYLOR FORGE

Why be satisfied with "just-as-good" welding fittings? WeldELLS alone offer you ALL these 8 aids to faster, easier pipe welding.

WeldELLS

Seamless Pipe Fittings for Welding

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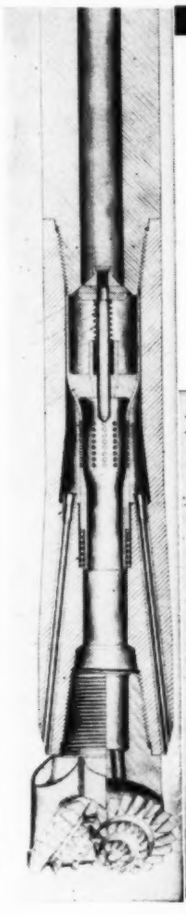
New York Office: 50 Church St.
Philadelphia Office: Broad Street Station Bldg.



Have You Seen This Modern-Marvel Tool For Rotary Drilling?

ACME'S MUD COLLAR

(Patents Allowed)

A SENSATION at the Oil Show! Spotlighted by the Oil Industry press! Praised by leading drillers! Already in successful operation in the field! Acme's Mud-Collar is 1940's PROVEN Wonder Tool for rotary drilling!

Its hi-velocity fluid jets, evenly spaced, strike bottom within the hole gage. Breaking up and hydration of bit cuttings mean "*no more balling up.*" Speeds drilling—with less power and strain on equipment. "Breaking circulation" on fishing jobs made easy.

The Mud-Collar's enthusiastic acceptance far exceeds early estimates. When ALL Rotary Drillers KNOW what it will do *for them*—the hazards it overcomes—the time and profits it saves—we won't be able to meet demand!

Order NOW through your Supply Store. Or write TODAY for complete information.

Acme Fishing Tool Co.

Parkersburg, West Virginia

Export Office:
19 Rector St., New York, N. Y.

For wells with production strings having slotted or round bored perforations

THE

CAVINS

PERFORATION

WASHER

1 Opens the perforations that are clogged with mud, sand, shale, etc.

2 Flushes the formation outside the pipe.

3 Prepares perforated pipe for cement jobs or water location.

4 Determines the condition of outside gravel-packed jobs.

The perforation Washer consists of the Cavins Automatic Hydraulic Suction Bailer and two attachments which can be assembled in 15 minutes' time.

(A companion tool to the Perforation Washer is the Screen Cleaner, designed for use in wire wrapped screen liners.)

THE CAVINS CO.

2853 Cherry Avenue

LONG BEACH, CALIFORNIA

Rental and Service Agencies:

Bakersfield, Taft, Ventura, Odessa, Corpus Christi, Houston, Kilgore, Lake Charles, Seminole, Wichita, Hoisington, Lance Creek, Denver

R. W. McIlvain, Jr., Called by Texas National Guard

R. W. McILVAIN, JR.

R. W. McIlvain, Jr., manager of the Texas Producing Division of Pure Oil Company, Fort Worth, Texas, has been called to service by the Texas National Guard and will report to Fort Bliss at El Paso on November 18. McIlvain is a First Lieutenant of the 124th Cavalry, Troop "B" of the 56th Cavalry Brigade.

H. J. McKenzie Made President Sterling Pump Corporation

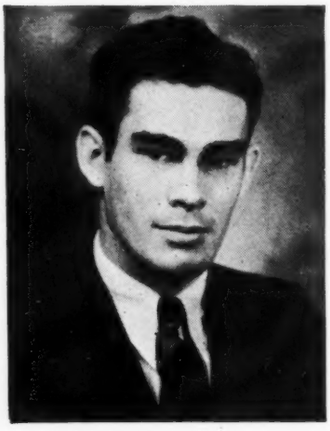
Henry J. McKenzie, executive vice-president and general manager of Sterling Pump Corporation, Hamilton, Ohio, manufacturers of deep-well turbine and centrifugal pumping units, has been appointed president of that corporation to succeed Maurice Rothschild, who will continue as a director.

F. W. Shelton Flies East

F. W. SHELTON

F. W. Shelton, assistant general manager of E. M. Smith Company, Los Angeles, California, manufacturer of Grizzly oil-field products, flew east via TWA's 4-engined luxury Stratoliner, for business conferences at several points. He expected to be gone about ten days.

K. N. Mills and L. W. Baker Join Bethlehem Supply



KENNETH N. MILLS

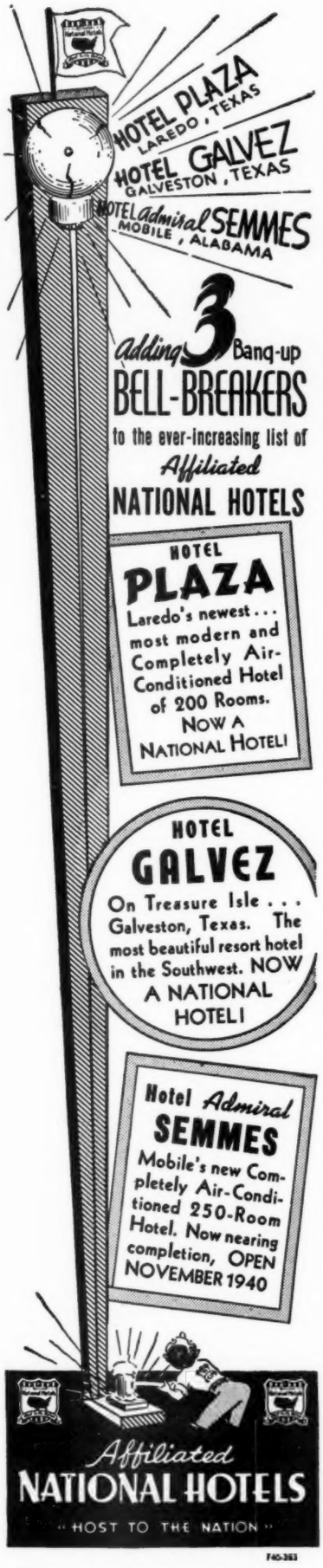
The Bethlehem Supply Company, Tulsa, Oklahoma, through G. A. Tompson, vice-president, announces the appointment of Kenneth N. Mills as chief engineer of its manufacturing division.

Mills was formerly chief engineer of the American Manufacturing Company of Texas. During his association with the petroleum industry, he has devoted considerable time to analytical studies of the problems encountered in oil-well pumping.

Bethlehem also announces the appointment of L. W. Baker as a sales representative in Tulsa to call upon the oil trade. Baker has been in Tulsa since 1927, coming from Bridgeport, Illinois, to join the staff of the First

L. W. BAKER

National Bank and Trust Company. Resigning his banking position in 1930, he became affiliated with the Lucey Products Company, later being named vice-president of the company. He resigned his connection with the latter company, effective September 15, to join the sales force of the Bethlehem Supply Company.



R. H. Clapp Assistant General Manager Roebling

ROGER H. CLAPP

The John A. Roebling's Sons Company, Trenton, New Jersey, announces the appointment of Roger H. Clapp, formerly Philadelphia branch manager, as assistant general manager of sales, with headquarters in Trenton.

Clapp, who was born in Worcester, Mass., on August 21, 1893, gained his first knowledge of the wire business with the American Steel and Wire Company in Worcester, where he spent six years in the mills and eight years in sales work.

In 1923, Clapp became sales manager of the Wire Department of the Wickwire Spencer Steel Company in New York City. Later he became Eastern District sales manager for Wickwire, and, in 1932, was promoted to the sales managership of their Pacific Coast Division.

Clapp went with the Roebling company in 1936 and was appointed manager of the Philadelphia branch.

W. A. Hanley Chosen President A.S.M.E.

William A. Hanley, director of Eli Lilly and Company, Indianapolis, Indiana, and head of its engineering division, was elected by a letter ballot of the 15,000 members of The American Society of Mechanical Engineers to be president of the organization.

Oil Company Promotes

Harry T. Klein has been named executive vice-president of The Texas Company. He has been a vice-president and general counsel and will continue to hold the latter post. C. E. Olmstead, vice-president in charge of refining, has been placed in charge of the export department. Michael Halpern, general manager of refining, has been named as vice-president and succeeds Olmstead.

A Secure and Profitable Metal Packing Investment

FRANCE "Full-Floating" Metal Packing is a secure investment. For nearly half a century, it has satisfactorily sealed compressor, engine and pump stuffing boxes regardless of pressure, temperature, vapor or gas conditions. It has proved its unexcelled qualities on machines, in every field of service. It is a profitable investment because of its long wearing qualities—all materials used in France Packings have proved their merits by time-tested experience. The packing rings are constructed from a metal best suited for the particular operating conditions encountered. The result, therefore, is maximum packing service with minimum maintenance expense.

Request FRANCE Metal Packing when ordering new machines. We specialize in prompt packing service for machines now in use.

Write for the free France Catalog M-3.

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Mid-Continent Representative:
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Fort Worth, Texas

Original
FRANCE
METAL PACKING

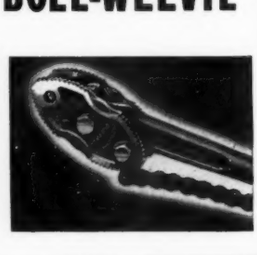
SUPREME
IN THE OIL FIELDS

GENUINE WILLIAMS' "VULCAN" CHAIN PIPE TONGS

Up and down the oil fields, you will find "VULCANS" doing the tough jobs just as readily as routine work. Every part of this famous tool is built to bear its share of the load. Chains are *proof-tested* and *certified*. Jaws and handle are tough drop-forgings . . . Through-Bolt is extra-heavy, and its U. S. Standard Nut simplifies replacement. 8 sizes, with Flat Link or Cable Chain, for ⅛ to 18″ pipe.

Also "VULCAN BOLL-WEEVIL"

A *reversible action* tong for flat pipe work—very efficient in trenches. Changes instantly from "making-up" to "breaking-out" without even unhooking chain. Jaws reversible for double life. Each chain *proof-tested* and *certified*. 4 sizes, ¾″ to 12″ pipe.



Write for complete Williams' catalog, or see our advertisement in The Composite Catalog. Buy from your supply store.

J. H. WILLIAMS & CO.
225 Lafayette St., New York, N. Y.

Interesting Program Prepared for Meeting A.I.M.E.

The Mid-Continent Section of the American Institute of Mining and Metallurgical Engineers will be host for the Annual Fall Meeting of the Petroleum Division, to be held at Tulsa, Oklahoma, October 24, 25, and 26. Headquarters for the meeting will be at the Mayo Hotel.

The program includes interesting papers by well-known engineers on such pertinent and timely subjects as retrograde condensation, the nature of hydrocarbon systems, capillarity in oil sands, subsurface sampling, subsurface engineering in recovery problems, oil-well cements, well shooting, temperature surveys, compressibility of reservoir rocks, and petroleum engineering education.

JOHN R. SUMAN
Incoming President of the A.I.M.E.

The three-day meeting also includes an interesting entertainment program. A stag buffet smoker will be held on Thursday night, October 24, at the Tulsa Club. Friday afternoon all those registered and their wives will be guests of Frank Phillips at the world-famous Woolaroc Ranch, where a barbecue dinner will be served in the evening. Visitors remaining until Saturday afternoon will have the opportunity to see a colorful homecoming football game between Tulsa University and Texas Christian University of Fort Worth. A large block of seats has been reserved for the game, and tickets will be available at the registration desk.

P. E. FITZGERALD, Chairman,
Mid-Continent Section, A.I.M.E.

Plans have been perfected for receptions, teas, and parties for the wives of visitors. A party is planned for late Thursday afternoon, October 24, to be followed by a dinner and social evening. It is tentatively planned also that a number of members and their wives will meet at a luncheon prior to the football game Saturday, October 26.

W. S. MORRIS, Chairman,
Papers and Program Committee,
Petroleum Division, A.I.M.E.

A. D. MacLean Elected Vice-President Pittsburgh Equitable

Colonel W. F. Rockwell, president of the Pittsburgh Equitable Meter Company, has announced the election of A. D. MacLean to the vice-presidency of the company.

A. D. MacLEAN

MacLean is a graduate of the School of Engineering, Harvard University. Immediately upon receiving his degree, he enlisted in the Army Air Service Corps, serving therein until the armistice in the World War. His first connection in industry was with the Ashton Valve Company of Cambridge, Massachusetts, as chief draftsman. He later accepted a position with the engineering department of the New Departure Division of General Motors Corporation and was subsequently promoted to assistant chief engineer.

In 1926 MacLean joined the Emco organization as chief engineer, which position he has filled until the present date.

MacLean is well known in industry as an author and lecturer on technical subjects.

Gordon M. Davidson Passes Away

Gordon M. Davidson, superintendent of operations and chief engineer of the Natural Gas Pipeline Company of America, passed away September 20 in Chicago, Illinois, after an illness of several months duration.

Davidson was born July 13, 1893, in Los Angeles, California. He graduated from Leland Stanford University, receiving a B.A. degree in mechanical engineering. He entered the service of The Empire Companies as draftsman November 3, 1919, and on July 21, 1921, was transferred to field construction on gasoline plants. On May 14, 1922, he returned to the general offices in Bartlesville, Oklahoma, as an engineer and from there progressed to general superintendent of the gasoline division of The Empire Companies.

Davidson joined the Natural Gas Pipeline Company of America as chief engineer on July 1, 1931, and on January 1, 1934, was promoted to superintendent of operations and chief engineer.

During his employment with The Empire Companies, he was active on committee work in the A.P.I. and Natural Gasoline Association of America. During his employment with the Natural Gas Pipeline Company of America, he took active part as a member of the A.P.I. Sectional Committee on Code for Pressure Piping; the A.P.I. General Committee of the Pipeline Transportation Division of Production, and as a member of the A.P.I. Sub-committee of the Natural Gas Division of Production.

Texas A. & M. Engineers Meet

The Petroleum Engineering Club of Texas A. & M. College held its first meeting of the year, 1940-41, on September 26, 1940, at which time Chester Naramore, assistant secretary of the A.I.M.E., delivered an address on the subject, "Think."

This New RIDGID Tri-Stand Vise Really Saves you work

LEGS fold up snug to go where your work is. Sets up rigid, hard to knock over — ceiling brace and screw-down feet, if you want to use them. Special malleable frame is a whole work bench — lots of room for oil cans, dope pots; slots to hang a flock of tools handy; pipe rest and three benders that won't collapse your pipe. Chain or yoke, with highest quality tool steel jaws. An outstanding value in convenience, built to take the punishment. Saves you work *AND* money. Buy from your Supply House.

New RIDGID Chain Tri-Stand. Capacity: 4"

THE RIDGE TOOL CO., ELYRIA, OHIO

RIDGID PIPE TOOLS

NEW LIGHT ON YOUR CLEANING JOBS

DE-SCALE DIESEL COOLING SYSTEMS SAFELY

When safety controls show your Diesel is overheating, it is a danger signal to quickly check! Lime scale and rust deposits in water jackets are usually the cause of poor heat transfer, yet they can be removed easily if you de-scale the cooling system the safe, low-cost Oakite way.

Simply circulate solution of Oakite Compound No. 32 and lime scale and rust deposits will be thoroughly removed. Jackets are left clear and clean ... your engine will run cool as it should.

FREE 20-page booklet gives all the details on this successful, widely used method. New THIRD EDITION just off the press ... write for YOUR copy today!

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We'll Send You "ROPE DOPE" regularly!
"Rope Dope" is *not* an advertising medium. It is a periodical bulletin which explains simply and intelligently the highly technical phases of Wire Rope—its applications and uses . . . There's no obligation on your part—but a lot of valuable information in store for you.
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Wire Ropes
The "ULTIMATE LOW COST WIRE ROPE"

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IT'S A HIT! Mounting orders for improved DURA PLASTIC Packing prove it has the stuff! Better sealing . . . greater resilience . . . uniform density. Available in bulk, coils or rings.

DURAMETALLIC CORPORATION
The PERFECT SEAL
KALAMAZOO MICHIGAN

Trade Literature

MACWHYTE COMPANY, Kenosha, Wisconsin, has issued a pamphlet entitled "The Why in Macwhyte Internally Lubricated Wire Rope," describing this defense against internal friction and corrosion that is built into Macwhyte wire ropes.

●

ALLIS-CHALMERS MANUFACTURING COMPANY, Milwaukee, Wisconsin, has published a catalog on its new "HD 7" Diesel crawler tractor. Five main features of the 54-hp. tractor are emphasized, as follows: (1) 2-cycle Diesel power; (2) balanced power speed; (3) bi-metallic clutches and brakes; (4) new track release mechanism, and (5) "positive-seal" truck wheels.

●

KOPPERS COMPANY, *American Hammered Piston Ring Division*, Baltimore, Maryland, has issued a group of leaflets that illustrate and describe its various types of piston rings. Among these are 4-cycle Diesel rings and assemblies; 2-cycle Diesel rings and assemblies, single acting and double acting, and Gold Seal piston rings.

●

A FOLDER issued by A. O. Smith Corporation, Milwaukee, Wisconsin, concerns Smithweld Pressure Vessels and describes advancements made in this field by the company in recent years. The folder is being sent to interested parties.

●

KOPPERS COMPANY, *Bartlett Hayward Division*, Baltimore, Maryland, has issued a catalog on Fast's Self-Aligning Coupling. The publication is well illustrated with diagrams as well as photographs of actual installations. Accompanying is a complete description of the principle, design, and application of the equipment.

●

THE DEVELOPMENT, properties, and manufacture of Integral-Joint Drill Pipe is described in a new bulletin, J & L Integral-Joint Blue Ribbon Drill Pipe, issued by Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

W. K. Mellon Now Making Headquarters in Houston

W. K. Mellon, vice-president of Petrolite Corporation, announces the transfer of his headquarters from the company's offices in Los Angeles, California, to the Gulf Coast Division offices at Houston, Texas. From this point he will supervise all Petroleum Rectifying Company of California operations in the eastern and Gulf Coast divisions, including the district offices at Houston, Texas, and Toledo, Ohio.

W. K. MELLON

Mellon first became connected with the Petroleum Rectifying Company of California in 1919, opening the Houston, Texas, branch, and pioneering in early dehydration work. Moving to Los Angeles in 1929, he was California district manager for a number of years, and in 1937 was elected vice-president of the company, in which capacity he was in charge of company operations.

Natural Gasoline Association Plans Active Year

Getting ready for an active year in its technical studies, the Natural Gasoline Association of America has announced the committee lists and activities for the fiscal year of 1940-1941. According to William F. Lowe, secretary-treasurer of the association, chairmen and vice-chairmen of the principal committees are as follows:

Economic Committee, J. R. Jarvis, Lone Star Gasoline Company, Dallas, Texas, chairman; H. E. Means, Coltexo Corporation, Monroe, Louisiana, vice-chairman.

Gas Contract Committee, R. A. Worley, Parade Gasoline Company, Inc., Shreveport, Louisiana, chairman; John T. Oxley, Warren Petroleum Corporation, Tulsa, Oklahoma, vice-chairman.

Gas Testing Committee, H. L. Oder, Cities Service Oil Company, Bartlesville, Oklahoma, chairman; H. D. McLean, Hercules Gasoline Company, Inc., Shreveport, vice-chairman.

Legal Committee, Wilbur J. Holleman, Glen Rose Gasoline Company, Tulsa, chairman; W. P. Z. German, Skelly Oil Company, Tulsa, vice-chairman.

Research and Educational Committee, B. R. Carney, Shell Oil Company, Inc., Tulsa, chairman; W. F. Fulton, United Gas Pipe Line Company, Shreveport, vice-chairman.

Specifications and Outage Committee, Howard E. Felt, Warren Petroleum Corporation, Tulsa, chairman; Harry Wheeldon, Lone Star Gasoline Company, Dallas, vice-chairman.

Technical Committee, C. R. Williams, Continental Oil Company, Ponca City, Oklahoma, chairman; H. H. Beeson, Sabine Valley Gasoline Company, Inc., Shreveport, vice-chairman.

Traffic Committee, F. A. Shellhorn, Hanlon-Buchanan, Inc., Tulsa, chairman; E. C. Kitching, Phillips Petroleum Company, Bartlesville, vice-chairman.

Kobe Appoints H. K. Browning Mid-Continent Sales Manager

Kobe, Incorporated, has announced the appointment of H. K. Browning as division sales manager, in charge of the Mid-Continent area, with headquarters in Tulsa, Oklahoma. The offices of C. M. Rader, division manager, will continue in the company's plant at Oklahoma City.

H. K. BROWNING

Browning was active for many years in technical sales work of the A. M. Byers Company, Pittsburgh, Pennsylvania. During the time Browning was with the Byers company, he held the positions of division sales manager in St. Louis, manager of Pacific Coast sales, and manager of oil-country sales, with headquarters in Pittsburgh. In 1934 Browning's interest in corrosion fatigue led to his association with the S. M. Jones Company of Toledo, Ohio, as sales manager, which position he has held for the last five years.

Rockford Clutches

...Give Ideal Power Control For Oil Field Jobs

Extremely sturdy, Rockford Industrial Clutches have everything it takes to give smooth, easy power transmission control on prospecting rigs as illustrated below and on a hundred and one other jobs in the oil field. They are made in two types, Over-Center and Spring-Loaded, and in a wide variety of diameters and capacities to fit every requirement. Investigate the economy and other important advantages of buying and using equipment employing Rockford Clutches. Write for further details today.

Tell manufacturers and dealers you want Rockford Clutches in your equipment... and why. Get all the facts. Write now!

ROCKFORD DRILLING MACHINE DIVISION
Borg-Warner Corporation
1303 Eighteenth Avenue, ROCKFORD, ILLINOIS, U. S. A.
Over-Center Clutches • Spring-Loaded Clutches • Power Take-Offs

THE BEST VALVE PROVIDES *Positive Closure*

A valve must provide positive closure, even after years of service in the open position. The *best* valve guarantees this effect with wide, *self-releasing* 30° angle wedges, and *flexible-action* gates which automatically adjust themselves to seats. It permits no pressure shock.

The best valve also assures smooth, positive operation by unwedging and freeing gates *before* raising, wedging them only when they are directly opposite ports. It cleans itself and has no internal guides to cause foul-up; it allows ready replacement of parts through ample tolerances.

Only the parallel seat, double wedge type slide gate valve provides *all* these essential benefits. This principle, developed and perfected by Ludlow, has been universally accepted and preferred for oil, gas, and water lines since 1866.

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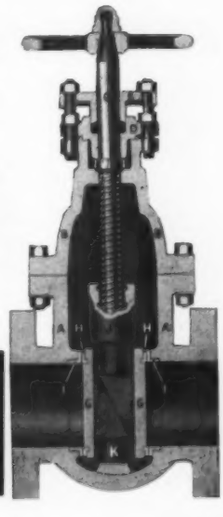

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Texas Oil Industry to Have 45 Derricks on Birthday Cake

The Texas oil industry will have 45 derricks on its birthday cake as it celebrates, under leadership of E. L. Smith, president of the Texas Mid-Continent Oil and Gas Association, the 45th anniversary of the opening of the Corsicana field.

Principal feature of the anniversary celebration will be the Texas Mid-Continent's annual meeting in Fort Worth, October 31-November 2, when a memorial plaque commemorating the birth of the Texas oil industry in October, 1895, will be presented representatives of Corsicana. A few days later, dedicatory ceremonies will be held at Corsicana, and the plaque erected on a scale derrick there.

The Texas Mid-Continent's anniversary meeting will be spudded-in by the world's first rotary drilling rig. Built about 1883 in South Dakota for water well drilling, the original rotary was brought to Corsicana soon after the completion of the first oil well there in October, 1895. It has been put into shape for drilling again, and with location staked on a vacant space adjoining convention headquarters in Fort Worth, the association will drill a wildcat test in the heart of downtown Fort Worth.

A number of other features honoring Texas petroleum pioneers also are being planned, and an elaborate entertainment program has been arranged for Texas oilmen and their wives.

Entertainment has been arranged by a committee consisting of Raymond Gee, chairman, E. A. Landreth, Houston Hill, H. S. Cole, Jr., John Farrell, James Snowden, Marshall Young, Harold Neely, Charles F. Roeser, and Jack Herbert. Plans for a reception honoring the visiting oilmen before the dinner-dance are being made by F. J. Adams, Sid W. Richardson, A. J. Armstrong, William Fleming, Edward Hudson, Paul McDermott, Rice Tilley, J. C. Halbert, R. O. Dulaney, P. W. Riggins, and Roy Westbrook. W. A. Moncrief is general convention chairman in charge of all arrangements.

A number of outstanding speakers will address the convention. Included will be R. B. Anderson of Vernon, former tax commissioner of Texas; George H. Sheppard of Austin,

State Comptroller; Guy Tate of Dallas, chairman of the forms simplification committee of the association; Raymond Myers of Dallas, chairman of the social security committee; Paul Pitzer of Breckenridge, chairman of the anti-theft committee; F. T. Baldwin of Houston, chairman of wages and hours committee; and Al Buchanan of San Antonio, chairman of the membership committee. Several out-of-state speakers are to be announced.

Business sessions will be devoted to discussion of current problems in the industry. Officers of the Texas Mid-Continent Oil and Gas Association are E. L. Smith of Dallas, president; H. R. Cullen of Houston, vice-president for the Gulf Coast; Bryan W. Payne of Tyler, vice-president for East Texas; J. L. Collins of Corsicana, vice-president for East Central Texas; D. Houston Bolin of Wichita Falls, vice-president for North Texas; M. B. Davis of Pampa, vice-president for the Panhandle; Hamilton McRae of Midland, vice-president for West Texas; Joe A. Clarke of Albany, vice-president for West Central Texas; Al Buchanan of San Antonio, vice-president for Southwest Texas; George C. Gibbons of Dallas, executive vice-president, and Eugene McElvaney of Dallas, treasurer.

Hewitt Rubber Dedicates New Building

Celebrating the completion of a plant-wide expansion and improvement program, Hewitt Rubber Corporation of Buffalo, New York, held open house on September 28, for its employees and their families. The occasion was marked by the presentation of service pins to 54 factory and office workers, bringing to 224 the number of employees who have thus received recognition for length of service.

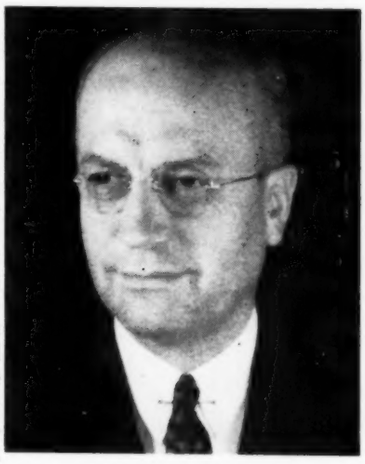
Formal dedication of the new building was made by Thomas Robins, Jr., president, with the unveiling of a bronze plaque on the second floor designating the name of the new building as "The Twombly Building," in honor of Earle K. Twombly, vice-president of manufacturing.

The general committee in charge of the program included William Brockner, Ray Cameron, A. D. Costin, Don Chamberlin, Paul Stein, Albert Kreier, and George Koch.

With the completion of this new building and the installation of the latest types of storage and mixing equipment Hewitt has materially increased its plant capacity and has succeeded in establishing scientifically accurate controls over all primary manufacturing processes.

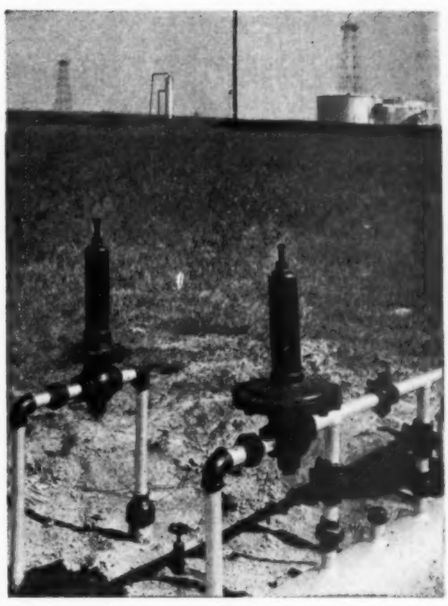
Earl N. Graf Moves Up With Roebling

Earl N. Graf, former manager of the Pittsburgh branch of the John A. Roebling's Sons Company, has been appointed assistant manager of sales, Wire Rope Division, with headquarters at Trenton, New Jersey.



EARL N. GRAF

Graf's first association with the Roebling company came indirectly in 1919, when he took over specialized wire rope sales for the Frick & Lindsay Company, a Roebling distributor in Pittsburgh. Frick & Lindsay later became the Frick-Reed Supply Corporation and Graf remained as the wire rope specialist with the new concern. He joined the Roebling staff in 1938 at Pittsburgh.



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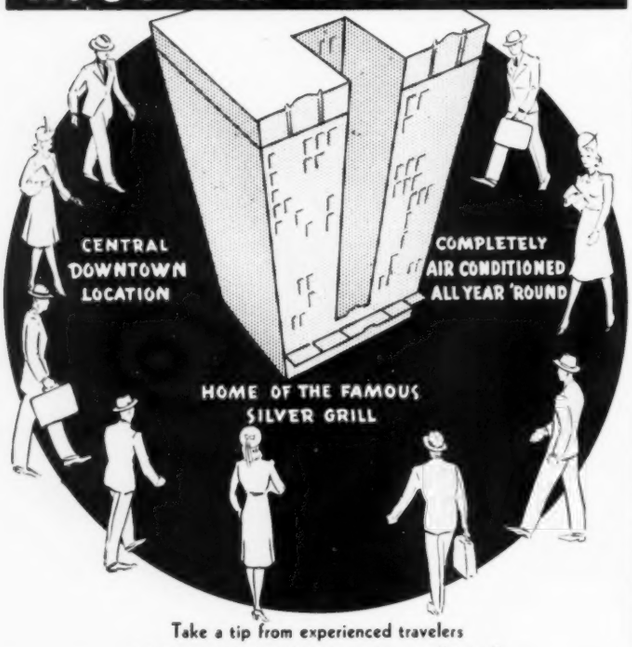

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Book Reviews

Conversion of Petroleum—Production of Motor Fuels by Thermal and Catalytic Processes by A. N. Sachanen. Published by Reinhold Publishing Corporation, 330 West 42nd Street, New York, New York, 398 pages, price $6.00.

This book relates to the fundamental principles and practices of converting petroleum products into gasoline and other fuels.

At the present time the conversion of petroleum can be carried out by various methods, including thermal and catalytic cracking, hydrogenation, polymerization, and alkylation. Unquestionably thermal cracking retains its position and remains thus far the most important process among the aforementioned methods of conversion. On the other hand, the part played by the other methods becomes of more and more importance, particularly in the production of high-octane fuels. The catalytic character of the other methods of conversion is emphasized in the title.

The author has realized the difficulties encountered in covering the broad problem of the conversion of petroleum in one volume and has therefore been confronted with limiting the scope of the book. A complete survey of the enormous literature on the subject in one volume of conventional size seems to be prohibitive. Therefore only the most important works, from the point of view of the author, have been referred to and discussed. The historical development of the conversion of petroleum is beyond the scope of the present book. As a consequence, many articles of an important historical value have not been included.

* * *

Procedure Handbook of Arc Welding Design and Practice. Published by The Lincoln Electric Company, Cleveland, Ohio. Sixth edition, 1940. Price, $1.50 in U.S.A., $2.00 elsewhere, postage prepaid.

Rapid progress in the development of the arc-welding process and its many applications has made available a large amount of new information on this subject. As a result, the Fifth Edition Procedure Handbook has been largely rewritten and expanded in contents. In addition to the careful attention given the subject matter of this new edition, care has been taken to improve the physical make-up of the book. The type matter and illustrations have been condensed and arranged so as to avoid as much waste of space as possible. Also the book is printed on a lighter, finer paper stock resulting in considerable reduction in size over the Fifth Edition in spite of the inclusion of twenty percent more material.

B and W, Inc., Opens Houston Office

B and W, Inc., well-completion specialists, recently opened Gulf Coast headquarters at 302 Merchants' and Manufacturers' Building, Houston, Texas. Distribution of wall-cleaning guides and other well-completion specialties will be under the supervision of Bruce Barkis.

BRUCE BARKIS

MEETINGS

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 24, 25, and 26, Tulsa, Oklahoma.

Western Petroleum Refiners Association, Regional Meeting—October 25, Shreveport, Louisiana.

Texas Mid-Continent Oil and Gas Association—October 31, November 1 and 2, Fort Worth, Texas.

California Natural Gasoline Association—November 1, Los Angeles, California.

American Recycling Association—November 5 and 6, Texas A & I College, Kingsville, Texas.

California Natural Gasoline Association, Monthly Meeting—November 7, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

American Association of Petroleum Geologists—November 7 and 8, Los Angeles, California.

American Petroleum Institute, 21st Annual Meeting—November 11, 12, 13, 14, and 15, Stevens Hotel, Chicago, Illinois.

American Institute of Mining and Metallurgical Engineers, Petroleum Division, East Texas Section—November 12, Kilgore, Texas.

American Institute of Chemical Engineers—December 2, 3, 4, 5, and 6, New Orleans, Louisiana.

National Asphalt Conference—December 9, 10, 11, 12, 13, and 14, Dallas, Texas.

Society of Automotive Engineers, Annual Meeting and Engineering Display—January 6, 7, 8, 9, and 10, 1941, Book-Cadillac Hotel, Detroit, Michigan.

North Texas Oil and Gas Association—February 22, 1941, Wichita Falls, Texas.

American Petroleum Institute, Southwestern District Division of Production — February 27 and 28, 1941, Washington-Youree Hotel, Shreveport, Louisiana.

American Petroleum Institute, Division of Production, Spring Meeting, Pacific Coast District — March 11, 1941, Biltmore Hotel, Los Angeles, California.

Indiana Independent Petroleum Association, Spring Convention and Refiners' and Suppliers' Exhibit—March 11, 12, and 13, 1941, Hotel Severin, Indianapolis, Indiana.

American Association of Petroleum Geologists—April 2, 3, and 4, 1941, Rice Hotel, Houston, Texas.

American Petroleum Institute, Eastern District, Division of Production—April 17 and 18, 1941, William Penn Hotel, Pittsburgh, Pennsylvania.

Petroleum Industry Electrical Association—April 23, 24, and 25, 1941, Tulsa, Oklahoma.

Natural Gasoline Association of America, Annual Meeting—April 23, 24, and 25, 1941, Baker Hotel, Dallas, Texas.

National Petroleum Association—April 24 and 25, 1941, Semiannual Meeting, Hotel Cleveland, Cleveland, Ohio.

American Society for Testing Materials—June 23, 24, 25, 26, and 27, 1941, 44th Annual Meeting, Palmer House, Chicago, Illinois.

D & B Store Opened at Freer, Texas

A new D & B pump sales and service store has been established at 644 Tipton Street in Freer, Texas. This new store will provide additional service to customers who purchase D & B pumps through the Continental Supply Company.

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